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SOLAR HOT WATER HEATER IN MONTANA: PERFORMANCE AND ECONOMIC ANAYLSIS MODEL

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SOLAR HOT WATER HEATING IN MONTANA: PERFORMANCE AND ECONOMIC ANAYLSIS MODEL

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Prepared for

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Introduction

Four % of the total United States energy consumption and 14 % of energy use in the residential sector is used for domestic hot water production (Hirst, 1980). With higher prices for conventional fuels used for this purpose, the economics of the substitution of solar becomes more attractive. A computer simulation of the cost of installing solar hot water (SHW) heating systems would be useful to home owners attempting to minimize energy related expenses.

Previous computer evaluations of solar domestic hot water heating such as TRNSYS (Klein et al., 1976), LASL (Balcomb, Hedstrom, 1976) and SOLCOST (Connolly et al., 1976) have focused on the relation of the collection area and local climate to the variations in the percentage (or "solar fraction") of hot water provided by solar systems. Each of these hourly simulations must be run on mainframe computers. This is clearly beyond the capabilities of lay persons who need such design tools.

DNRC has developed an easy to use solar domestic hot water program designed to run on microcomputers. The DNRC program is based on the FCHART method (Duffie and Beckman, 1980), a widely accepted approach to estimating the solar fraction by simulating the performance of a solar system. This method allows prediction of comparative solar vs. conventional fuel costs based on predicted performance, and use of monthly data inputs. The simulation model developed by DNRC is an interactive BASIC computer program consisting of four discrete sections: an analysis of energy demand, a collector performance algorithm, a specification of economic parameters, and a series of sensitivity tests. The availability of recent solar data for 30 sites around Montana permits analysis by geographic region.

Comparison to Other Programs

A simplified FCHART has been publicly available in the Montana Solar Data Manual for over two years. It allows analysis of both active solar hot water and space heating systems using a hand calculator and work sheets. The method is simplified for ease of use, but may be cumbersome for some lay persons.

The DNRC SHW analysis model is a public domain program, formatted to run on Apple II microcomputers, which are widely available at schools, universities and businesses around the state. It uses the FCHART algorithm (see Appendix A) in a detailed form to predict solar hot water system output and costs. The DNRC model makes several improvements to the simplified FCHART:

1) The program is interactive in a friendly fashion. Questions are displayed on the screen and answers are requested from the keyboard. No mathematic skills are required for the inputs. Computations are fast and automatic with a typical runtime of less than five minutes for a complete analysis. There is extensive error checking in the program, so that erroneous data is not entered. Default values are provided for all questions based on typical responses. It is possible to print a summary of the analysis results to a printer.

2) The water heating load is calculated with good accuracy. Effects of occupant consumption behavior are incorporated as well as a mathematical model for predicting effect of household size on consumption. Seasonal fluctuation in mains water temperature has been studied in Missoula and Helena, and an excellent lagged linear fit to monthly ambient temperatures has been derived.

3) Additional correction factors are included for minimum acceptable hot water temperature and thermal losses from the auxilary storage tank, which have significant effects on SHW system performance (see Appendix A).

4) An economic analysis section is included that allows rapid optimization of collector size. Sensitivity study of the effect of a variety of economic parameters is easily accomplished. These parameters could include local utility rates, energy cost escalation and general inflation rates, length of period covered by analysis, and loan interest rates.

5) Solar and climatological data is available for thirty sites around Montana, allowing wide application of the program.

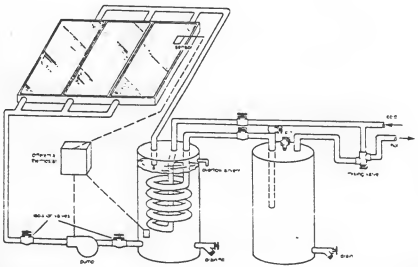
6) Specific assumptions are made on the efficiency of home built and self installed systems based on measured results (Winn, 1981).

In the last year the Montana Power Company has incorporated FCHART and the Fowlkes data for implementing SHW into their zero interest loan program. The DNRC model uses essentially the same calculation algorithm although some of the load calculations are more specific. The program, however, is designed to be easy to use for the average lay person and is publicly available. The greatest disparity between the two programs is the economic assumptions used on fuel price escalation rates in the respective reference cases. The DNRC assumptions are considerably more conservative in this respect, although the effect of comparable escalation rates is easily studied.

Physical Description of Simulated Solar Systems

The computer simulation example used in this report is based on the physical characteristics of the "drainback" type of collector, a common type of solar hot water system in Montana. (Performance characteristics for other types of systems may be entered in the model if desired. Systems using air as the heat transfer medium can't be simulated with DNRC's model.) A schematic of the system is shown in Figure 1. In this configuration, typical flat plate collectors convert solar radiation to heat. That heat is transferred to water that moves via riser tubes to a solar storage tank. This tank contains a heat exchanger that heats cold line water before it enters the conventional hot water heater. Water can only reach the collectors when the pump is turned on by the thermostat. When the pump turns off, the collector system drains naturally, leaving the array empty and freeze-proof. The water in the storage tank is isolated from tap water, eliminating the long term calcination problems that otherwise would occur with drainback systems.

Figure 1. - Drain back Solar System Configuration



The collectors used in the examples here are liquid, selective surface double-glazed collectors. However, values for any liquid collector system may be substituted in the program by the user to allow analysis of any conventional configuration. Solar storage and auxiliary tanks are assumed to be insulated to R-10. A ratio of two gallons of water for solar storage is assumed per square foot of collector surface.

Collector Performance Algorithm

Thermal performance of the collectors is analyzed in order to determine system output. The factors involved in such analysis are very complex thermodynamic processes. The DNRC model uses the FCHART method developed by Beckman et al. (1977) to simulate collector performance. FCHART is based on hundreds of runs of the TRNSYS simulation and has been extensively validated against actual system performance. Agreement with experimental results is considered to be very good for conventional collector designs. Duffie and Mitchell (1982) have compared annual performance of eleven solar hot water systems with predicted performance using the FCHART method. Agreement with measured solar fractions was within $\pm$ 3 percent annually. The calculation method is described in detail in Appendix A.

Data Accuracy

Inaccuracies in the model estimations can occur at several points. The radiation and climatological data used in the calculation procedure has a substantial effect on the results. Inaccuracy in the FCHART collector performance algorithm, though minimal, may compound this problem.

The radiation and climatological data is taken from the Montana Solar Data Manual (Fowlkes, 1981). The solar data is based on an instrumented thirty site network within the state. Approximately five years of continuous data has been developed during the program. Extensive calibration and data correction efforts have put the data accuracy to within a ± 5 percent confidence interval. The data recovery rate has been in excess of 80 percent. The greatest drawback of the solar data is the relatively short time period covered.

The climatological data is from the U.S. Weather Service 30-year long term averages. A cursory analysis of this data for various Montana locations shows a standard deviation of 15 percent for year-to-year measured temperatures from local long term averages (NOAA, 1982).

Generally, given the most probable cumulative inaccuracies of the algorithm, climatology and behavioral aspects, model estimates can be bounded by approximately a ± 16 percent confidence interval for any given year.

Economic Optimization Algorithm - Parameters

The initial costs of solar hot water systems are dependent on the size of the collectors. The solar fraction increases with collection area but at a steadily diminishing rate. Therefore, it would be prohibitively expensive to size a system to provide all household hot water year-round. Determining the economic parameters for the financial analysis allows estimation of the most economic system size.

The fixed and variable costs for commercial SHW systems were derived by performing a linear regression of cost data compiled by McPherson (1980) and Sawyer (1978). These costs were significantly lower for home built systems. Some of the initial cost of commercial systems can be reduced by purchasing equipment and performing an owner installation.

Table 1 summarizes the fixed and variable cost assumptions in the model. Data for 1978 and 1979 were inflated by use of the consumer price index to 1982 dollars. Phone calls to four Montana solar hot water system dealers found this price data to be in close agreement with current system costs (Parker, 1983).

Table 1

Fixed and Variable Costs of Solar Systems

	Owner Built And Installed	Commercially Built and Installed	Commercial Unit/ Owner Installed
Fixed	$500	$1200	$700
Variable (ft^2)	$ 20	$ 30	$ 30

Sources: McPherson, B., 1980. Hot Water From the Sun; U.S Dept. of Housing and Urban Development, HUD-PDR-548, Washington, D.C.;
Sawyer, S.W., 1978. Cost Performance and Reliability Patterns of 177 Solar Heating Systems; Proceedings of the Solar Heating and Cooling Operations Results Conference, SERI, Colorado Springs, Colorado.

The cost of conventional energy was taken from the January, 1983, residential rates for each location in the solar data base. This information is presented in Table 2. Although all gas suppliers have winter rates for the first fifteen MCF of consumption, it is assumed in the model that the avoided gas cost in these months will be at the higher rate. Most customers with gas water heating also have gas space heat which will consume the lower cost gas.

Table 2
Residential Electricity and Natural Gas Prices

Utility	Electricity (kWh)	N-Gas (MCF)
Montana Power Company	$ .036	$ 4.672
Montana-Dakota Utilities	.069	3.945
Pacific Power and Light[1]	.03/ .048 .063	NA
Flathead Irrigation Proj.[2]	.013/.019	NA
Glacier Electric Coop	.028	NA
Fall River Electric Coop	.037	NA
Great Falls Gas	NA	5.175

NA - Not applicable
[1] Rate Structure: 0-300 kWh = $.0304, 301-1000 = $.0448, 1000+ = $.06265, minus $.00781 Exchange Credit
[2] <900 kWh = $.013 kWh, >900 = $.019
MDU = Glasgow, Glendive, Miles City, Plentywood, Sidney
PP&L = Kalispell, Libby
Flathead Irrigation Project = Polson
Glacier Electric Cooperative = Browning
Fall River Electric Cooperative = West Yellowstone
MPC = Most others
Great Falls Gas = Great Falls area

Source: T. Otis, Phone Conversation, Public Service Commission, January 4 and April 27, 1983.

Twenty years was assumed as the most likely life expectancy for an active solar system of the type depicted (Beckman et al., 1977). This agrees closely with the "mean-time-before-system failure" estimates of Goldberg (1978).

Past studies have underscored the importance of the assumed discount rate for solar-economic models. The real fuel price escalation rate is similarly important (Chandra, 1977). Short-term fuel price escalation rates were taken from the forthcoming Montana Power Company 1983 forecast (Antonioli, 1983) in which real rates of increase were estimated at 6 percent and 4 percent annually for electricity and natural gas over a ten-year period. The long-term real fuel price escalation rate is taken from Nordell (1983) in which rates for natural gas and electricity are

estimated at 2.5 % per year. The Montana Power Company uses 4 percent and 6 percent average real escalation rates for electricity and natural gas prices over the entire 20-year period in their analyses of SHW systems for their zero interest loan program. While such rates greatly increase solar savings, the DNRC assumptions are more conservative for long term projections. Regardless, these assumptions are only little better than educated guesses.

The individual discount rate is input into the model based on whether or not the purchaser plans to borrow money to pay for the solar system. If the purchaser uses his own money, the solar system can be treated as an investment. A nominal 11 % discount rate is then assumed, which corresponds to a best alternative investment for an individual in a 35 % tax bracket. Inflation is assumed to be 8 % per year in the simulation. Consequently, the model uses a real 2.78 % discount rate; that is the nominal rate over inflation (1.11/1.08 = 1.0278). If the purchaser finances the system, the model uses a 13 % interest rate over the life of the investment, or 4.6 % real. This is lower than the 7.9 % real rate (16.5 % nominal) currently used by the federal government in evaluating energy related investments (Marshall & Ruegg, 1980). The high rate used by the government tends to discourage large investments with slow rates of return such as solar. It is also considerably greater than the average individual long-term discount rate (Ibbotson and Sinquefield, 1979).

Both state and federal tax credits are included in DNRC's model. The current federal tax credit allows taxpayers to write off 40 % of the initial investment up to $10,000. The state credit is in addition to the federal credit. It is currently 5 % of the first $1,000 of the investment and 2 1/2 % of the next $3,000 up to a maximum credit of $125 (I.R.S., 1982; Montana Department of Revenue, 1982).

Operation and maintenance and pumping and controller energy costs of the system are set according to convention at 1 % of the initial investment per year (Duffie and Beckman, 1980). They are projected to increase at the general rate of inflation, thus remaining constant in real terms. The system is assumed to have no salvage value after twenty years. The conventional gas system and auxiliary gas backup for the solar system are slated for replacement in the tenth year.

Economic Optimization - Method

Life-cycle cost analysis is used to translate future cost and benefit streams into present value dollars. This allows direct comparison of solar versus conventional options. Optimization of the solar design area is reached at the collector area that maximizes positive differences between life-cycle costs of the two options. This will result in the greatest savings for the owner. The model estimates a variety of economic measures that allow assessment of comparative life-cycle costs and savings, time to recover investment, and dollar savings compared to dollars invested. All are presented so that persons familiar with a particular method will be able to compare the results in terms of what they understand best.

The present value of O&M and replacement costs are calculated using the uniform present worth equation:

$$P = A \frac{(1 + d)^n - 1}{d\,(1 + d)^n}$$

$$P = A \frac{(1 + d)^n - 1}{d\ (1 + d)^n}$$

Where: A = cost of O&M in the first year

d = discount rate (.0278 or .046)

n = life of investment (20 years)

The modified uniform present worth (UPW*) of future fuel costs uses a similar approach modified by the fuel escalation rate:

$$UPW^* = P_n \sum_{n=1}^{10} \frac{1}{[(1 + d)/(1+r)]^n} + \sum_{n=11}^{20} \frac{1}{[(1+d)/(1+e)]^n}$$

Where: d = discount rate (.0278 or .046)

n = year (1-20)

r = fuel price escalation rate, years 1 to 10 (.04 gas, .06 electricity)

e = fuel price escalation rate, years 11-20 (.025)

Using the nomenclature of Marshall and Ruegg, (1980), life cycle costs of the two options is represented by:

$$LCC = P - S + M + R + E$$

Where: P = purchase and installation costs

S = salvage value

M = Present value of O&M costs

R = present value of auxiliary heater replacement

E = present value of energy costs

Calculation of the present value of net savings results in a single number that is readily comparable for ranking purposes. This calculation determines the difference between the life-cycle costs of the solar investment and the conventional alternative:

$$NS = E - (P - S + M + R)$$

Where: E = reduction in present value energy costs

P = differential purchase and installation costs

S = differential salvage value

M = differential present O&M value costs

R = differential present value replacement costs

The solar area that maximizes the net savings of the solar investment is the criteria used for optimization. The program increments the solar area by one square meter until the greatest net savings is reached.

Two other analytical tools are used to rank the solar system economic performance. The savings investment ratio differs from the two previous methods in that it provides a measure of the economic efficiency (rate of return) of an investment. For positive net savings, the ratio must be greater that one - the higher the ratio, the more dollar savings realized per dollar of investment. Using the same nomenclature as with the previous example:

$$SIR = \frac{(E - M)}{(P - S + R)}$$

The greatest SIR will often be that reached prior to reaching the most economic size of investment, so the SIR is not the preferred method for optimization. However, it is valuable for comparative project ranking.

The discounted payback measures the time between the initial point of investment and a time in the future when net accumulated savings offset the initial costs. The method is most often used with investments where a rapid turnover of investment funds is desirable. However, a shorter payback does not indicate the most economically efficient investment.

$$DPB = \frac{\log_e \left[1 + \frac{C_1}{S_1} * (e-d) \right]}{\log\left(\frac{1+e}{1+d}\right)}$$

where:

C_1 = initial costs minus tax credits

S_1 = first year solar savings minus O & M costs

d = discount rate

e = fuel price escalation rate

Sample Case Parameters

The manner in which DNRC's program works can be demonstrated with a sample case. In the case shown below, the economics of solar domestic hot water were calculated for a family of four in Helena. The exact method for determining the hot water load is detailed in Appendix B. Briefly, the thermal load varies monthly from a low of 1.7×10^6 Btu in August to 2.1×10^6 Btu in March. The model estimates that 73 gallons of hot water is used each day requiring 6,912 kWh of annual electricity to meet the demand, including standby losses. The set temperature of the water tank is 140°F. It is assumed that external insulation (R-10 wrap) has already been applied to the auxiliary tank before solar is considered.

Location of the residence determines the amount of solar energy available to meet the demand and the cost of competing conventional fuels. The available average daily incident radiation per square foot in Helena, Montana, based on actual measurement (Fowlkes, 1981), is shown in Table 3, The house is assumed to have an unobstructed south facing exposure.

Table 3.

Available Insolation

Helena, Montana* (Btu/ft^2/day)

Winter			Spring		
Dec.	Jan.	Feb.	Mar.	April	May
679	805	1035	1327	1508	1362

Summer			Fall		
June	July	Aug.	Sept.	Oct.	Nov.
1605	1627	1640	1649	1337	964

* For a solar collector facing due solar south, inclined 45^o from horizontal.

Source: Fowlkes, Charless, 1982. Montana Solar Data Manual, DNRC, Helena, Montana, p. 12 and 13.

Results and Sensitivity

The sample computer run for the electricity case is contained along with the program itself in Appendix C. The optimal collector size for the system is 9 m^2 or about 96 ft^2 corresponding to the size necessary to heat most of summer hot water and 70 % of annual hot water demands. About 2,000 kWh of electricity is used annually to provide the other 30 % of the hot water demand. The estimated initial capital cost of the system is $4,124, or $2,349 after federal and state tax credits. The life-cycle cost of the solar system is $4,541 versus $5,376 for the conventional system, for a net savings of $835. The savings investment ratio is 1.35; the discounted payback is 16 years.

Table 4 tests the model sensitivity to number in the household (1-6 persons), hot water consumption habits, and tank temperature set point. It is assumed that "miserly" users will consume about one-third fewer gallons of hot water than average users; "lavish" users will consume 30 percent more.

Table 4. - Sensitivity to Number in Household/Habits

	Natural Gas			Electric		
	Optimal ft^2	'F'	Net Savings	Optimal ft^2	'F'	Net Savings
# in Household						
4 ref. case	64	.53	$-241	96	.70	$835
1	21	.44	-752	32	.63	-434
2	32	.44	-576	53	.66	21
3	53	.53	-406	75	.68	441
5	75	.53	- 85	107	.68	1203
6	86	.53	67	129	.70	1558
4 miserly use	43	.49	-474	64	.66	272
4 lavish use	86	.55	- 5	118	.69	1384
4 120° set temp	53	.57	-303	75	.73	590

F = Annual fraction of hot water provided.

A three-person household is the economic break even point for electricity, while household habits that increase use of hot water (lavish use) or use of higher temperature water tend to favor solar investment. A conversion from natural gas to solar is not cost effective in most cases. Note that a collector of the same size will not provide the same solar fraction for electric and natural gas systems. This is because the natural gas water heater cannot be insulated as well as the electric one, presenting a greater thermal load. (See Appendix B.) Reducing the water heater set temperature to 120° results in substantial present value savings ($230 for electricity) at no investment cost.

Table 5 studies variations in performance and economics from various collector types. The collector used as the reference case is a good double glazed collector. Three other configurations are modeled, including average double and single glazed collectors and an evacuated tube model. The average values are based on a random sample of thirty single and double glazed models from the Solar Products Specifications Guide. (Solar Age, 1981).

Table 5. - Sensitivity to Collector Type

	Natural Gas			Electric		
	Optimal ft^2	'F'	Net Savings	ft^2	'F'	Net Savings
Reference Case	64	.53	$-242	96	.70	$ 835
Housebuilt	86	.51	374	107	.59	1,326
Ave. Double glazed	53	.40	-480	86	.58	401
Ave. Single glazed	53	.40	-462	86	.58	406
Evacuated Tube	75	.60	-219	107	.78	994
Uninsulated Tank	75	.59	123	96	.70	1,283

Notes:	$F_R U_L$	$F_R \tau\alpha$
Ref. Case	.68	.72
Ave. Double Glazed	.81	.67
Ave. Single Glazed	.95	.72

As seen from this analysis, there is little difference between average single and double glazed collector performance, the primary deciding factor being one of price. Considerably greater life-cycle savings are possible if the solar system is self-built even though such systems are assumed to have reduced efficiency. The approximate 8 % increase in efficiency possible from adding hot water tank insulation significantly increases solar savings in cases where this will not be undertaken without solar retrofit. Evacuated tube collector designs offer greater efficiency although at a cost greater than that of a standard flat plate system.

Table 6 tests sensitivity to the effects of financing, zero interest utility loans and fuel price escalation rates. The test case system is not economic when financed with a high interest loan. This benefit-cost analysis is very sensitive to the discount rate and fuel price escalation rates chosen. DNRC explicitly assumed that fuel price escalation rates will be in addition to inflation.

Table 6. - Sensitivity to Financing Method and Fuel Price Escalation Rate

	Natural Gas			Electric		
	Optimal ft^2	'F'	Net Savings	ft^2	'F'	Net Savings
Reference Case	64	.53	$-242	96	.70	$ 835
Financed	53	.46	-477	86	.66	349
0-Interest Loan	86	.64	354	107	.74	1,931
1 percent FP escal.rate	53	.46	-425	86	.66	506
5 percent FP escal.rate	86	.64	229	107	.74	1,618

Reid and Hendricks (1977) noted the pronounced effect of the federal tax credit on the financial attractiveness of solar. This provision of the 1978 Conservation Tax Act is slated to expire in 1984 and its renewal is uncertain. Table 7 explores

effects of a discontinued federal tax subsidy and also of the effect of increasing the Montana state tax credit to 20 percent of initial costs. Results of solar competing with electricity price at its marginal cost $.07/kWh (Duffield, 1979) are also shown. This measure is important because while the individual choice to install a solar collector is based on the average costs of fuels, the actual benefit to society is that the SHW system displaces the need of new electricity generation capacity. The cost of this new capacity - marginal cost - typically is much higher than the average cost.

Table 7. - Sensitivity to Tax Subsidy/Marginal Cost Pricing

	Natural Gas			Electric		
	Optimal ft^2	'F'	Net Savings	ft^2	'F'	Net Savings
Reference Case	64	.53	$-241	96	.70	$835
No Federal Tax Credit	21	.21	-1229	53	.47	-566
20 percent State Tax Credit	86	.64	348	107	.74	1546
Marginal Cost Electricity	---	---	------	118	.77	4637

Without the federal tax credit solar cannot compete economically with conventional energy sources. A 20 % state tax credit does improve the financial attractiveness, especially for conversion from natural gas. If electricity were priced at its marginal cost, the reference case system would provide the greatest present value savings of any sensitivity performed.

Uncertainty Analysis

In the economic analysis of solar options, several economic parameters are estimated with varying degrees of uncertainty. These include the discount rate, inflation rate and fuel price escalation rates. Future energy price projections are especially uncertain, yet they have profound effect on the results of the cost benefit analysis. The problems with forecasting future energy prices are demonstrated in the following examples.

In a 1976 report from the Montana Energy Advisory Council, Stroup (1976) projected Western Montana natural gas prices through the year 1990. At that time (end of 1976) the residential price of natural gas was $1.66 per MCF; the report projected the 1980 gas price at $2.34 in constant 1976 dollars. At the close of 1980 the price of natural gas was $4.07/MCF - $3.03 when deflated to 1976 constant dollars. Projections were made that the price of gas would increase at an annual rate of 8.6 percent per year - certainly not a conservative estimate. The actual annual percent growth rate was 15 percent! Furthermore, Stroup assumed that growth in natural gas prices would be essentially flat in the 1980s, increasing to $2.40/MCF (1976 dollars) by 1990. This point actually was passed in 1979.

In a companion report Duffield (1977) predicted that average electricity prices would increase at about 2 percent in real terms over the period 1973-1990. Specifically, in the base case, a 15.2 percent cumulative increase in constant 1976 dollars was forecast for 1973-1980 period corresponding to a 2.36 percent annual percent growth rate. Converting residential electric rates into 1976 dollars, the actual commulative rate of increase was 11.8 percent, a 1.80 percent annual growth rate. This is good agreement with actual events, but does overestimate the real

In either case the predictions were in error. Stroup correctly anticipated large increases in natural gas prices, but not nearly large enough. On the other hand, Duffield made a conservative guess for electricity prices but not conservative enough. The probability of forecasting future energy prices with accuracy seems low.

Analysis for a period of twenty years is even more uncertain than the two short-term cases just examined. The DNRC model was a long-term real fuel escalation rate of 2.5 percent. A short-term (ten year) escalation rate of 4.0% for natural gas and 6.0% for electricity is assumed. For purposes of a sensitivity analysis, we could assume that the fuel price escalation rate is uncertain such that the actual value for 'e' over the period may vary ± 2 percent from the value DNRC used.

We will also assume that the individual discount rate is uncertain such that the actual value of "d" over the period may vary ± 1% from the value used (2.78%). The uncertainty in either variable is approximated by:

$$\Delta NS = \frac{\partial NS}{\partial x_i} \Delta x_i$$

Where: ΔNS = change in the present value of net savings

∂NS = differential of net savings over the period

∂x_i = differential value of the parameter (discount rate or fuel price escalation rate)

Δx_i = the change in "x_i" examined

For the analysis, the same reference case system (four person household, in Helena with an 80 square foot collector array) is used. Electricity savings in the first year amounts to $157. Use of the reference case economic values yields a net

savings of $804 over the period. Uncertainty in the discount and escalation rates affect the value of "UPW*" as shown in the equation on page 11. As a result the uncertainty in net savings generated by the discount rate is such that the net savings may vary ± $333. The same calculation for the fuel price escalation rate yields a ± $665 uncertainty. The maximum uncertainty generated by variations in the two parameters is simply the sum of the two: ±$998.

However, based on Brandemuehl and Beckman (1979), the "most probable" uncertainty in net savings is given by:

$$NS_{prob} = \sqrt{\sum_{i=1}^{N=2} \left(\frac{\partial NS}{\partial x_i} \Delta x_i \right)^2}$$

so that the most probable uncertainty generated by the two parameters = ± $744. Since the base case net savings is only $804, the analysis indicates that with only a two percent uncertainty in future fuel prices and one percent uncertainty in the discount rate, the actual life cycle savings may range from $1,548 to only $61. This ranges from excellent savings to almost none! This underscores the sensitivity of the long-term savings predicted by any SHW system simulation to even small variations in exceedingly uncertain future fuel prices and discount rates. This uncertainty is true not only for solar investments but also for those involving conventional fuels.

Ranking Solar Thermal of Thirty Montana Sites

Powlkes (1981) has measured insolation and climatic data for 30 Montana locations. SHW analysis was performed for each of these sites to establish geographic variation in solar potential. The base case assumptions (four person

Ranking Solar Thermal of Thirty Montana Sites

Fowlkes (1981) has measured insolation and climatic data for 30 Montana locations. SHW analysis was performed for each of these sites to establish geographic variation in solar potential. The base case assumptions (four person household, average hot water use) were used for the ranking procedures. The ranking results, based on delivered solar energy, are presented in Table 8 and Figure 2. An 80-square-foot collector array is assumed. Although the model's absolute accuracy is uncertain, the ordinal ranking is at least approximately accurate. The major caveat in this assessment is the short-term nature of the Fowlkes data. Regardless, the measured Fowlkes data is more believable than SOLMET estimates previously available from the U.S. Weather Service.

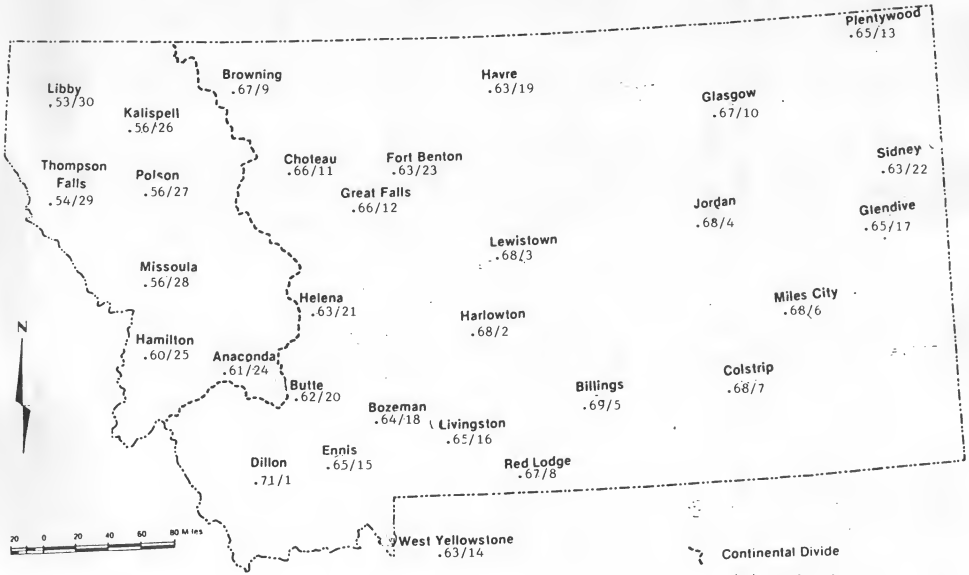
Table 8.
Solar Thermal Ranking of 30 Montana Sites

	"Fraction$_1$"	Solar Heat Collected$_2$	Rank
Dillon	.71	16.1	1
Harlowton	.68	15.5	2
Lewistown	.68	15.5	3
Jordan	.68	15.5	4
Billings	.69	15.4	5
Miles City	.68	15.4	6
Colstrip	.68	15.4	7
Red Lodge	.67	15.4	8
Browning	.67	15.4	9
Glasgow	.67	15.2	10
Choteau	.66	15.0	11
Great Falls	.66	15.0	12
Plentywood	.65	15.0	13
West Yellowstone	.63	14.8	14
Ennis	.65	14.7	15
Livingston	.65	14.7	16
Glendive	.65	14.6	17
Bozeman	.64	14.5	18
Havre	.63	14.4	19
Butte	.62	14.4	20
Helena	.63	14.3	21
Sidney	.63	14.3	22
Fort Benton	.63	14.2	23
Anaconda	.61	13.9	24
Hamilton	.60	13.6	25
Kalispell	.56	12.9	26
Polson	.56	12.7	27
Missoula	.56	12.7	28
Thompson Falls	.54	12.1	29
Libby	.53	12.1	30

Notes: 80 ft^2 solar collector; $F_R U_L$ = .68, $F_{R\,T\alpha}$ = .72
4 person occupancy, average hot water use, tank set point of 140°F

1 percentage of thermal load provided by solar collectors
2 10^6 Btus/year

Figure 2
Montana Solar Hot Water Thermal Performance Ranking



The Economic Ranking

The economic ranking of the thirty Montana solar sites varies appreciably from the thermal potential ranking. This is because current prices of energy differ across the state depending on the utility or local cooperative supplier. Electricity prices have the greatest range of variance. Hydroelectric power in the Flathead Irrigation Project service area is only $.019/kWh while thermally produced electricity in the MDU service area is $.069/kWh. Natural gas is not available in some sites.

The economic ranking is presented in Table 9 and Figure 3. There is greater uncertainty in this analysis than the physical one. Only low confidence is possible in estimates of the real energy price escalation rates and how they might vary from one utility to another.

Table 9

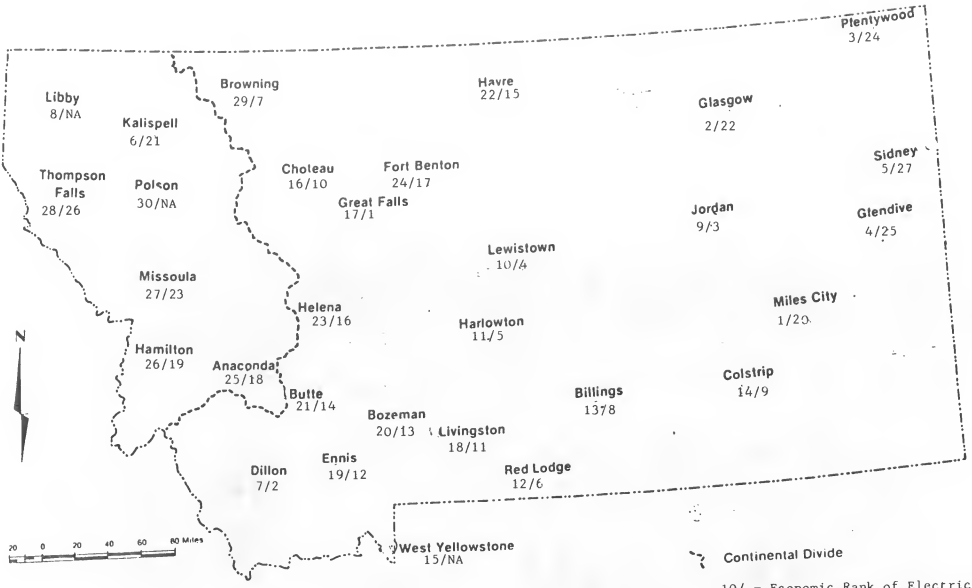
Solar Economic Ranking of 30 Montana Sites

(Arranged in order or rank)

ELECTRICITY			NATURAL GAS		
List of Towns	Net Savings	Rank	List of Towns	Net Savings	Rank
Miles City	$4,396	1	Great Falls$_2$	$ 104	1
Glasgow	4,344	2	Dillon	24	2
Plentywood	4,233	3	Jordan	- 60	3
Glendive	4,044	4	Lewistown	- 63	4
Sidney	3,931	5	Harlowtown	- 72	5
Kalispell$_1$	1,412	6	Red Lodge	- 79	6
Dillon	1,226	7	Browning	- 80	7
Libby$_1$	1,156	8	Billings	- 83	8
Jordan	1,103	9	Colstrip	- 86	9
Lewistown	1,099	10	Choteau	-149	10
Harlowtown	1,086	11	Livingston	-192	11
Red Lodge	1,079	12	Ennis	-196	12
Billings	1,071	13	Bozeman	-223	13
Colstrip	1,065	14	Butte	-232	14
W. Yellowstone	1,040	15	Havre	-242	15
Choteau	975	16	Helena	-267	16
Great Falls	964	17	Fort Benton	-282	17
Livingston	911	18	Anaconda	-330	18
Ennis	908	19	Hamilton	-371	19
Bozeman	867	20	Miles City	-475	20
Butte	855	21	Kalispell	-488	21
Havre	841	22	Glasgow	-490	22
Helena	804	23	Missoula	-517	23
Fort Benton	780	24	Plentywood	-524	24
Anaconda	714	25	Glendive	-581	25
Hamilton	652	26	Thompson Falls	-615	26
Missoula	439	27	Sidney	-617	27
Thompson Falls	296	28	Libby		N/A
Browning	264	29	W. Yellowstone		N/A
Polson	- 983	30	Polson		N/A

Notes: 80 ft^2 solar collector; $F_R U_L$=.68, $F_R \tau\alpha$ =.72
4 person occupancy, average hot water use, energy cost summary from Table 3.
1-mean of rate tiers. See Table 2.
2-Great Falls gas price, all others are MPC, MDU.

Figure 3
Montana Solar Hot Water Economic Performance Ranking



10/ = Economic Rank of Electricity
4 = Economic Rank of Natural Gas

Summary

Based on the simulation model assumptions, solar hot water heating is competitive with electricity in Montana but is not competitive with natural gas hot water heating. Optimal collector size is about 64-96 square feet for a family of four - the larger figure for solar against electric heating. The greatest problem is the long payback time involved because of the large initial costs.

Factors such as larger households or other influences that increase hot water use tend to favor solar investments. Self-built systems are considerably cheaper than the commercial variety although resulting system efficiency may be lower. Owner installed systems seem to offer no significant advantage given the risk of a poor installation. (See Appendix A)

Solar hot water heating is not economically viable in Montana without the federal tax credit. An increased state tax credit would increase solar's economic competitiveness - especially for natural gas users.

Any economic evaluation model is particularly susceptible to distortions stemming from selection of the discount rate, fuel price escalation rates and assumptions regarding future inflation. Special care should be taken in specification of these values. The effect of the uncertainty of these values has been illustrated. A 2 % variation in the fuel price escalation rate and a 1 % uncertainty in the discount rate could have the effect of negating any solar economic benefit or conversely, would triple life cycle solar savings.

Lower borrowing rates and higher inflation favors solar investments in that effective discount rates are reduced. Study of the impact of various policy oriented incentive programs for solar investment is easily accoumplished with the model. If electricity were priced at its marginal cost ($.07/kWh), solar would currently be very competitive in all locations.

Fowlkes (1982), having measured the variation in solar flux at 30 sites in Montana, found that eastern sites receive greater amounts. The economic attractiveness of solar hot water heating in Montana tended to follow these findings. The best sites are east of the Continental Divide. The worst are located in western Montana. A typical 80 square foot collector array would provide 53 to 71 percent of the annual hot water needs in the various locations. First year savings ranged widely from about $70 in Polson to over $300 in Miles City.

The economic ranking of the sites differs considerably from the thermal ranking because of the large effect of local conventional energy prices. The higher natural gas rates in the Montana Power Company system tended to favor those sites for solar over sites served by Montana-Dakota Utilities. However, Montana-Dakota Utility electric rates are currently the highest in Montana at 6.9 cents per kWh. The solar sites in this area (Glasgow, Plentywood, Miles City) had the shortest payback periods examined (7 years). The inverted rate structure of the PP&L area (Kalispell, Libby) has the effect of greatly favoring solar as monthly electrical consumption increases above 1,000 kWh, as is the case with homes using electric resistive heating. The attractiveness of SHW in the co-ops examined varied depending on their current rate structure.

The greatest economic barrier to utilization of the sun's energy is the high initial cost of the systems and the comparatively low avoided cost of conventional energy consumption. One may assume that the full potential for reducing the initial costs of solar systems has not yet been realized. For instance, development of new polymer film solar collectors promises to reduce materials and manufacturing costs of collectors by an order of magnitude (Wilhelm and Andrews, 1982). Advertised kit systems seem to offer substantially lower prices. Advanced evacuated tube systems promise high performance, although costs must be reduced somewhat to be commercially attractive. Given this, we may expect the initial cost of the systems to decrease in real terms.

There is evidence that consumer time horizons for energy investments are not appreciably greater than five years (Cunningham and Lopreato, 1977). As we have seen, even the most favorable analysis has larger paybacks than this. However, most large scale hydro-power sites, the lowest cost energy sources in Montana, have been exploited. New additions to generation capacity will usually consist of thermal conversion facilities with higher priced electricity. Further, the real price of conventional fuels is likely to increase over the long term, and coupled with any reduction in manufacturing costs, this would greatly increase the life-cycle savings of solar.

Solar hot water heating is now only provisionally economic in Montana. It is probable that long-term real fuel price increases will bring the technology into common use in the state by the twenty-first century.

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APPENDIX A

THE FCHART ALGORITHM

Two dimensionless parameters are calculated - "X" and "Y" that, when correlated, yield "F" - the monthly solar fraction:

$$X = \frac{A_c F_r U_L (T_{ref} - \overline{T_a})\ \Delta t}{L}$$

$$Y = \frac{A_c F_r (\overline{\tau\alpha}) \overline{H_t} N}{L}$$

where:

A_c = collector area (m^2)

F_R = collector - heat exchanger efficiency factor

U_L = collector heat loss coefficient (W/M^2C^o)

Δt = number of seconds in the month

$\overline{T_a}$ = monthly average ambient temperature (C^o)

T_{ref} = reference temperature (100^oC)

L = monthly heating load (Joules)

$\overline{H_t}$ = monthly average radiation incident on the collector surface (J/m^2)

N = days per month

$\overline{\tau\alpha}$ = monthly average transmittance-absorbance product

The products $F_r U_L$ and $F_r \tau\alpha$ are determined from controlled collector tests and then modified by a heat exchanger penalty factor: $\left(\frac{F_r'}{F_r}\right)$

which is assumed to be .96 for typical units. Tau-alpha is modified by the collector incident angle to yield a corrected absorbance transmittance product. This is assumed to be .94 for standard double glazed designs.

To use FCHART for hot water heating systems, an additional correction factor for "X" must be calculated. The main water supply temperature and minimum acceptable hot water temperature both effect collector thermal losses. "X_c" is calculated:

$$\frac{X_c}{X} = \frac{(11.6 + 1.18T_w + 3.86\ T_m - 2.32\ T_a)}{(100 - T_a)}$$

Where: $\frac{X_c}{X}$ = multiplier for X_c

T_w = minimum acceptable hot water temperature (C^o)

T_m = mains water supply temperature

T_c = monthly average ambient temperature (C^o)

A correction factor must also be calculated for the monthly load. This factor must take into account thermal losses from the auxiliary tank, which are expressed as:

$$L_{aux} = UA\ (T_w - T'_a)$$

Where: U = thermal loss coefficient (W/m^2)

A = area of tank

T_w = temperature of hot water

T'_a = ambient air temperature around storage tank

In the model the auxiliary tank is assumed to be of standard design with R-10 external insulation: "U" which accounts for both tank and plumbing losses is given to be .62 W/m^2 (electric) and .82 w/m^2 (gas), A is 3.21 m^2, T_w = 60°C and T'_a is 16°. The corrected load factor is:

$$L_{c,i} = L_i + L_{aux}$$

The results are two dimensionless variables X_c and Y that show the reference collector heat loss and solar gain over the load. Based on these values, the monthly solar fraction is derived mathematically using a power series correlation for liquid systems:

$$F_{month} = 1.029Y - .065X - .245Y^2 + .0018X^2 + .0251Y^3$$

The fraction of the annual load supplied by solar is the sum of monthly solar contributions ($\Sigma F_i L_i$), divided by the annual load (ΣL_i).

$$F_a = \frac{\sum_{i=1}^{12} F_i L_i}{L_i}$$

The fraction may be examined for different collector areas, locations, and collector types. These configurations may then be compared in the life-cycle costing methodology.

The FCHART algorithm has demonstrated less predictive capability when applied to non-conventional collectors, improperly installed units and homebuilt systems of unknown specification (Winn, 1981). Winn found that FCHART typically overestimates the fraction of these systems by 22 percent. Consequently, the monthly fraction predicted for homebuilt systems has been uniformly reduced by 20 percent for the purposes of the analysis. Owner installed systems have been decreased by 10 percent because of the risk of poor installation.

Appendix B

1) The size of the demand for hot water in a household of four is calculated as follows:

Based on data collected by Bavir et al. (1981) per person water consumption is best described by an exponential decay function according to the equation:

$$Q = P^* (A * p^{-x})$$

$$Q = P^* (23.4 * (P)^{-.18}$$

$$(R^2 = .725)$$

Where:

Q = gallons of hot water used per day

P = number of people in the household

x = fitted exponential coefficient

A = the regression intercept

2) Cold water line temperature varies from 40° F. in late winter to 60° in early fall. This is based on a year-long measurement of mains water temperature by month in two western Montana sites. A Weksler Fahrenheit thermometer was used to take the measurements in Missoula and Helena on the 15th of each month. The thermometers were calibrated monthly. The relationship is a lagged-linear expression assuming the residual values to be serially independent.
The function is of the form:

$$T_W = .38\ T_{A-1} + 33.4$$

$$(R^2 = .991)$$

Where: T_{A-1} = ambient temperature in previous month

T_W = water temperature in current month

3) The hot water tank set temperature is 140°F (Palmiter and Baylin, 1982).

4) The average heat necessary to heat this quantity of water is calculated:

$$L_i = Q * VT (T_h - T_c)$$

Where: L = daily thermal load (Btus/day) in month "i"

Q = gallons consumed per day

VT = volumetric weight of water (8.33 lbs/gal.)

T_h = hot water set temperature

T_c = mains water temperature

Monthly fuel demand is calculated:

$$G = \frac{(D_i * L)}{(HC * EG)}$$

G = monthly fuel consumption (mcf, kwh)

Where: D = number of days in month "i"

HC = heat content of natural gas at an altitude of 4,000 ft. (924,000 Btu/ft^3) or 1 kWh of electricity (3413 Btus).

EG = fractional efficiency in delivering heat content of natural gas or electricity to water including standby losses. (natural gas: .47 no external insulation, .55 insulated to R-11; electricity: .76 no external insulation, .85 insulated to R-11 Farahan, 1977, Ek, 1981).

```
?SYNTAX ERROR
ALIST

100  REM
110  REM ************************
120  REM *                      *
130  REM *   SOLAR HOT WATER    *
140  REM *   ANALYSIS MODEL     *
150  REM *                      *
160  REM ************************
170  REM
180  REM
190  TEXT
200 JA$ = "JANUARY":FB$ = "FEBRUARY"
210 MR$ = "MARCH":AP$ = "APRIL"
220 MY$ = "MAY":JE$ = "JUNE"
230 JL$ = "JULY":AG$ = "AUGUST"
240 SP$ = "SEPTEMBER":OT$ = "OCTOBER"
250 NV$ = "NOVEMBER":DC$ = "DECEMBER"
260 D$ =  CHR$ (4): REM  CTRL D
270  DEF  FN C(X) = (X - 32) / 1.8: DEF  FN F(X) = X * 1.8 + 32
280  DIM F1$(30),A(40),N(100),V(100),P(100)
281  HOME : INVERSE : GOSUB 21380: PRINT "       * DO YOU HAVE A PRINT
     ER?";: GOSUB 21380: GOSUB 21380: NORMAL : PRINT
282  PRINT "    1) YES": PRINT "    2) NO": PRINT
283 CV = 2:PF = 0:LO = 1:HI = 2: GOSUB 39300
284  IF CV = 1 THEN PF = 1
285  IF PF THEN  HOME : INVERSE : GOSUB 21380: PRINT " *IN WHICH SLOT
      IS THE INTERFACE CARD?";: GOSUB 21380: GOSUB 21380: NORMAL : PRINT

286  IF PF THEN CV = 1:LO = 1:HI = 8: GOSUB 39300:PS = CV
290  GOSUB 10400: REM INTITIALIZE CITY FILE NAMES
300  GOSUB 10050: REM  READ CITY FILE
310  GOSUB 10530: REM  READ DEFAULTS
320  REM
330  REM * REASSIGN VARIABLES *
340  REM
350 A1 = A(1):A2 = A(2)
360 A3 = A(3):A4 = A(4)
370 A5 = A(5):A6 = A(6)
380 A7 = A(7):A8 = A(8)
390 A9 = A(9):A0 = A(10)
400 AY = A(11):AZ = A(12)
410 A(10) = A0:A(11) = AY
420 I1 = A(13):I2 = A(14)
430 I3 = A(15):I4 = A(16)
450 I5 = A(17):I6 = A(18)
470 I7 = A(19):I8 = A(20)
480 I9 = A(21):I0 = A(22)
500 IA = A(23):IB = A(24)
501  IF IA + IB < 1550 THEN 510
502 I1 = I1 * .94:I2 = I2 * .96:I3 = I3 * 1.02:I4 = I4 * 1.08
503 I5 = I5 * 1.13:I6 = I6 * 1.15:I7 = I7 * 1.14:I8 = I8 * 1.1
504 I9 = I9 * 1.04:I0 = I0 * .98:IA = IA * .95:IB = IB * .93
506  GOTO 520
510 I1 = I1 * .98:I2 = I2 * .99:I3 = I3 * 1.04:I4 = I4 * 1.08
511 I5 = I5 * 1.12:I6 = I6 * 1.15:I7 = I7 * 1.14:I8 = I8 * 1.1
512 I9 = I9 * 1.04:I0 = I0 * .99:IA = IA * .96:IB = IB * .96
```

```
520 I1 = I1 * .0113538:I2 = I2 * .0113538
530 I3 = I3 * .0113538:I4 = I4 * .0113538
540 I5 = I5 * .0113538:I6 = I6 * .0113538
550 I7 = I7 * .0113538:I8 = I8 * .0113538
560 I9 = I9 * .0113538:I0 = I0 * .0113538
570 IA = IA * .0113538:IB = IB * .0113538
620 A1 = (A1 - 32) / 1.8:A2 = (A2 - 32) / 1.8:A3 = (A3 - 32) / 1.8:A4
    = (A4 - 32) / 1.8
630 A5 = (A5 - 32) / 1.8:A6 = (A6 - 32) / 1.8:A7 = (A7 - 32) / 1.8:A8
    = (A8 - 32) / 1.8
640 A9 = (A9 - 32) / 1.8:A0 = (A0 - 32) / 1.8:AY = (AY - 32) / 1.8:AZ
    = (AZ - 32) / 1.8
 650  HOME
 660  REM
 670  REM
 680  TEXT : HOME : INVERSE : GOSUB 21380: PRINT "     * ENTER THE NUM
     BER OF PEOPLE";: GOSUB 21380: PRINT "          IN YOUR HOUSEHOLD";
     : GOSUB 21380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT
 690 CV = ZP:LO = 1:HI = 100: GOSUB 39300:ZP = CV:P = ZP
 700  REM
 710  REM
 720  HOME : INVERSE : GOSUB 21380: PRINT "     * HOW WOULD YOU CHARACT
     ERIZE";: GOSUB 21380: PRINT "          YOUR HOT WATER USAGE?";: GOSUB
     21380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT
 730  NORMAL
 740  PRINT "1) MISERLY"
 750  PRINT "2) AVERAGE"
 760  PRINT "3) LAVISH": PRINT
 770 CV = PY:LO = 1:HI = 3: GOSUB 39300:PY = CV
 780  IF PY = 1 THEN Q = 16.4 * P ^  - .18
 790  IF PY = 2 THEN Q = 23.4 * P ^  - .18
 800  IF PY = 3 THEN Q = 30.4 * P ^  - .18
 810 ED = 8.33
 820  REM
 830  REM
 840  INVERSE
 850  HOME : INVERSE : GOSUB 21380: PRINT "       * ENTER HOT WATER TE
     MP";: GOSUB 21380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT
 860 CV =  FN F(TH):LO = 40:HI = 212:: GOSUB 39300:TH =  FN C(CV)
 870  REM
 880  REM
 890  HOME : INVERSE : GOSUB 21380: PRINT "       * HOW ARE YOU INSTAL
     LING";: GOSUB 21380: PRINT "          THE SOLAR SYSTEM?";: GOSUB
     21380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT :
 900  PRINT "1) BUILDING/INSTALLING YOURSELF"
 910  PRINT : PRINT "2) BUYING IT/COMMERCIAL INSTALLATION"
 920  PRINT : PRINT "3) BUYING IT/INSTALLING YOURSELF": PRINT
 930 CV = FA:LO = 1:HI = 3: GOSUB 39300:FA = CV
 940  REM
 950  REM
 960  HOME : INVERSE : GOSUB 21380: PRINT "          * HOW WILL YOU FIN
     ANCE";: GOSUB 21380: PRINT "          THE INSTALLATION?";: GOSUB
     21380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT
 970  PRINT "1) A BANK OR OTHER LOAN"
 980  PRINT "2) USE IT AS AN ALTERNATIVE INVESTMENT"
 990  PRINT "3) LOW INTEREST UTILITY LOAN": PRINT
1000 CV = AA:LO = 1:HI = 3: GOSUB 39300:AA = CV
1010  IF AA = 1 THEN D = .046
1020  IF AA = 2 THEN D = .0278
1030 ZQ = AA
```

```
1040  IF AA = 3 THEN D = .0000001
1050 T1 = .38 * AZ + 7.46
1060 T2 = .38 * A1 + 7.46
1070 T3 = .38 * A2 + 7.46
1080 T4 = .38 * A3 + 7.46
1090 T5 = .38 * A4 + 7.46
1100 T6 = .38 * A5 + 7.46
1110 T7 = .38 * A6 + 7.46
1120 T8 = .38 * A7 + 7.46
1130 T9 = .38 * A8 + 7.46
1140 T0 = .38 * A9 + 7.46
1150 TA = .38 * A0 + 7.46
1160 TB = .38 * AY + 7.46
1165  HOME : INVERSE : GOSUB 21380: PRINT "*ENTER CURRENT PRICE OF EL
     EC. PER KWH";: GOSUB 21380: GOSUB 21380: NORMAL : PRINT : PRINT
     : PRINT
1167 CV = CG:LO = .01:HIGH = .12: GOSUB 39300:CG = CV
1170  REM
1180  REM
1190  HOME : INVERSE : GOSUB 21380: PRINT "      * HOW DO YOU THINK TH
     E PRICE OF";: GOSUB 21380: PRINT "        ELECTRICITY WILL RISE";
     : GOSUB 21380: PRINT "        OVER THE NEXT 20 YEARS?";: GOSUB 21
     380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT
1200  PRINT "1) SLOWLY (1%/YR)"
1210  PRINT "2) MODERATELY (3%/YR)"
1220  PRINT "3) RAPIDLY (5%/YR)"
1230  PRINT "4) VERY RAPIDLY (10%/YR)": PRINT
1240 CV = QE:LO = 1:HI = 4: GOSUB 39300:QE = CV
1250  IF QE = 1 THEN ES = .01
1260  IF QE = 2 THEN ES = .025
1270  IF QE = 3 THEN ES = .05
1280  IF QE = 4 THEN ES = .10
1282  HOME : INVERSE : GOSUB 21380: PRINT "* ENTER FED TAX OR FCT FOR
     ANALYSIS";: GOSUB 21380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT

1284 CV = TX:LO = 0:HI = 75: GOSUB 39300:TX = CV
1290 WT = D * 3.78544 * P * 4190
1300 L1 = (WT * (TH - T1) * 31) / 10 ^ 9
1310 L2 = (WT * (TH - T2) * 28) / 10 ^ 9
1320 L3 = (WT * (TH - T3) * 31) / 10 ^ 9
1330 L4 = (WT * (TH - T4) * 30) / 10 ^ 9
1340 L5 = (WT * (TH - T5) * 31) / 10 ^ 9
1350 L6 = (WT * (TH - T6) * 30) / 10 ^ 9
1360 L7 = (WT * (TH - T7) * 31) / 10 ^ 9
1370 L8 = (WT * (TH - T8) * 31) / 10 ^ 9
1380 L9 = (WT * (TH - T9) * 30) / 10 ^ 9
1390 L0 = (WT * (TH - T0) * 31) / 10 ^ 9
1400 LA = (WT * (TH - TA) * 30) / 10 ^ 9
1410 LB = (WT * (TH - TB) * 31) / 10 ^ 9
1420 HC = .0036
1430  REM
1440  REM
1450  HOME : INVERSE : GOSUB 21380: PRINT "          * IS YOUR HOT WA
     TER";: GOSUB 21380: PRINT "          TANK INSULATED?";: GOSUB
     21380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT
1460  PRINT "1) YES"
1470  PRINT "2) NO": PRINT
1480 CV = Z:LO = 1:HI = 2: GOSUB 39300:Z = CV
1490  IF Z = 1 THEN EG = .85
1500  IF Z = 2 THEN EG = .76
```

```
1510 EH = HC * EG
1520 G2 = L2 / EH:G1 = L1 / EH
1530 G3 = L3 / EH:G4 = L4 / EH
1540 G5 = L5 / EH:G6 = L6 / EH
1550 G7 = L7 / EH:G8 = L8 / EH
1560 G9 = L9 / EH:G0 = L0 / EH
1570 GA = LA / EH:GB = LB / EH
1580  REM
1590  REM
1600  HOME : INVERSE : GOSUB 21380: PRINT "       * MONTHLY KWH OF ELE
     CTRICITY";: GOSUB 21380: PRINT "            TO HEAT WATER";: GOSUB
     21380: GOSUB 21380: NORMAL : PRINT
1605 LM = 5: GOSUB 22120: PRINT
1610  PRINT JA$;" =";: TAB( 20);: INT (G1)
1620  PRINT FB$;" =";: TAB( 20);: INT (G2)
1630  PRINT MR$;" =";: TAB( 20);: INT (G3)
1640  PRINT AP$;" =";: TAB( 20);: INT (G4)
1650  PRINT MY$;" =";: TAB( 20);: INT (G5)
1660  PRINT JE$;" =";: TAB( 20);: INT (G6)
1670  PRINT JL$;" =";: TAB( 20);: INT (G7)
1680  PRINT AG$;" =";: TAB( 20);: INT (G8)
1690  PRINT SP$;" =";: TAB( 20);: INT (G9)
1700  PRINT OT$;" =";: TAB( 20);: INT (G0)
1710  PRINT NV$;" =";: TAB( 20);: INT (GA)
1720  PRINT DC$;" =";: TAB( 20);: INT (GB)
1730  PRINT : PRINT
1740 AG = G1 + G2 + G3 + G4 + G5 + G6 + G7 + G8 + G9 + G0 + GA + GB
1745 LM = 0: GOSUB 22120
1750  PRINT : PRINT "ANNUAL KWH USE =";: TAB( 19);: INT (AG)
1760  PRINT : PRINT "HIT ANY KEY TO CONTINUE . . .";: GET AK$
1770 UA = .62 * 3.21 * (TH - 16)
1780 ST = (UA * 30.4 * 24 * 3600) / 10 ^ 9
1790 L1 = L1 + ST:L2 = L2 + ST
1800 L3 = L3 + ST:L4 = L4 + ST
1810 L5 = L5 + ST:L6 = L6 + ST
1820 L7 = L7 + ST:L8 = L8 + ST
1830 L9 = L9 + ST:L0 = L0 + ST
1840 LA = LA + ST:LB = LB + ST
1850 ZL = (L1 + L2 + L3 + L4 + L5 + L6 + L7 + L8 + L9 + L0 + LA + LB)
      * .9479
1860  GOSUB 5720
1870  GOSUB 5470
1880 P = ZP
1890  HOME : INVERSE : GOSUB 21380: PRINT "       * WOULD YOU LIKE TO
     HAVE";: GOSUB 21380: PRINT "          THE SYSTEM SIZED FOR YOU?";
     : GOSUB 21380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT
1900  PRINT "1) YES": PRINT "2) NO": PRINT
1910 CV = B0:L0 = 1:HI = 2: GOSUB 39300:B0 = CV
1915 X1 = X1 * 5.67
1920  IF B0 = 2 THEN 2010
1930  HOME : INVERSE : GOSUB 21380: PRINT " * PLEASE STAND BY WHILE T
     HE COLLECTOR";: GOSUB 21380: PRINT "        SIZE IS OPTIMIZED";: GOSUB
     21380: GOSUB 21380: NORMAL
1935  GOSUB 22200:TM = Y5 + 1: PRINT : PRINT : PRINT : GOSUB 22100
1940 SA = 1
1960  GOSUB 3870
1970 SA = SA - 1
1980  TEXT : HOME : INVERSE : GOSUB 21380: PRINT "  * OPTIMAL COLLECT
     OR AREA, SQ FT=";: INT (SA * 10.7639);: GOSUB 21380: GOSUB 21380:
      NORMAL : PRINT : PRINT : PRINT
```

```
1990 SB = SA
2000  PRINT : PRINT : PRINT "HIT ANY KEY TO CONTINUE . . .";: GET AK$

2010  HOME : INVERSE : GOSUB 21380: PRINT "      * WHAT COLLECTOR AREA
     ";: GOSUB 21380: PRINT "        WOULD YOU LIKE ANALYZED?";: GOSUB
     21380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT
2020 CV = (SA * 10.7639):LO = 10:HI = 15000: GOSUB 39300:SA = CV
2030 SA = SA / 10.7639
2040 A = 11.6:B = 1.18
2050 C = 3.86:E = 2.32
2060 EX = .94
2070 RF = 100
2080 X = SA * X1 * (RF - (A1)) * 31 * 24 * 3600 / (L1 * 10 ^ 9)
2090 X = X * (A + (B * TH) + (C * T1) - (E * A1)) / (RF - (A1))
2100 Y = Y1 * EX * I1 * 10 ^ 6 * 31 * SA / (L1 * 10 ^ 9)
2110 P1 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
2120 X = SA * X1 * (RF - (A2)) * 28 * 24 * 3600 / (L2 * 10 ^ 9)
2130 X = X * (A + (B * TH) + (C * T2) - (E * A2)) / (RF - (A2))
2140 Y = Y1 * EX * I2 * 10 ^ 6 * 28 * SA / (L2 * 10 ^ 9)
2150 P2 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
2160 X = SA * X1 * (RF - (A3)) * 31 * 24 * 3600 / (L3 * 10 ^ 9)
2170 X = X * (A + (B * TH) + (C * T3) - (E * A3)) / (RF - (A3))
2180 Y = Y1 * EX * I3 * 10 ^ 6 * 31 * SA / (L3 * 10 ^ 9)
2190 P3 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
2200 X = SA * X1 * (RF - (A4)) * 30 * 24 * 3600 / (L4 * 10 ^ 9)
2210 X = X * (A + (B * TH) + (C * T4) - (E * A4)) / (RF - (A4))
2220 Y = Y1 * EX * I4 * 10 ^ 6 * 30 * SA / (L4 * 10 ^ 9)
2230 P4 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
2240 X = SA * X1 * (RF - (A5)) * 31 * 24 * 3600 / (L5 * 10 ^ 9)
2250 X = X * (A + (B * TH) + (C * T5) - (E * A5)) / (RF - (A5))
2260 Y = Y1 * EX * I5 * 10 ^ 6 * 31 * SA / (L5 * 10 ^ 9)
2270 P5 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
2280 X = SA * X1 * (RF - (A6)) * 30 * 24 * 3600 / (L1 * 10 ^ 9)
2290 X = X * (A + (B * TH) + (C * T6) - (E * A6)) / (RF - (A6))
2300 Y = Y1 * EX * I6 * 10 ^ 6 * 30 * SA / (L6 * 10 ^ 9)
2310 P6 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3).
2320 X = SA * X1 * (RF - (A7)) * 31 * 24 * 3600 / (L7 * 10 ^ 9)
2330 X = X * (A + (B * TH) + (C * T7) - (E * A7)) / (RF - (A7))
2340 Y = Y1 * EX * I7 * 10 ^ 6 * 31 * SA / (L7 * 10 ^ 9)
2350 P7 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
2360 X = SA * X1 * (RF - (AB)) * 31 * 24 * 3600 / (LB * 10 ^ 9)
2370 X = X * (A + (B * TH) + (C * TB) - (E * AB)) / (RF - (AB))
2380 Y = Y1 * EX * IB * 10 ^ 6 * 31 * SA / (LB * 10 ^ 9)
2390 PB = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
2400 X = SA * X1 * (RF - (A9)) * 30 * 24 * 3600 / (L9 * 10 ^ 9)
2410 X = X * (A + (B * TH) + (C * T9) - (E * A9)) / (RF - (A9))
2420 Y = Y1 * EX * I9 * 10 ^ 6 * 30 * SA / (L9 * 10 ^ 9)
2430 P9 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
2440 X = SA * X1 * (RF - (A0)) * 31 * 24 * 3600 / (L0 * 10 ^ 9)
2450 X = X * (A + (B * TH) + (C * T0) - (E * A0)) / (RF - (A0))
2460 Y = Y1 * EX * I0 * 10 ^ 6 * 31 * SA / (L0 * 10 ^ 9)
```

```
2470 P0 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.0018 * X ^ 2)
     + (.0215 * Y ^ 3)
2480 X = SA * X1 * (RF - (AY)) * 30 * 24 * 3600 / (LA * 10 ^ 9)
2490 X = X * (A + (B * TH) + (C * TA) - (E * AY)) / (RF - (AY))
2500 Y = Y1 * EX * IA * 10 ^ 6 * 30 * SA / (LA * 10 ^ 9)
2510 PA = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.0018 * X ^ 2)
     + (.0215 * Y ^ 3)
2520 X = SA * X1 * (RF - (AZ)) * 31 * 24 * 3600 / (LB * 10 ^ 9)
2530 X = X * (A + (B * TH) + (C * TB) - (E * AZ)) / (RF - (AZ))
2540 Y = Y1 * EX * IB * 10 ^ 6 * 31 * SA / (LB * 10 ^ 9)
2550 PB = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.0018 * X ^ 2)
     + (.0215 * Y ^ 3)
2560  IF P1 > 1 THEN P1 = 1
2570  IF FA = 1 THEN P1 = P1 * .8
2580  IF FA = 3 THEN P1 = P1 * .9
2590  IF P2 > 1 THEN P2 = 1
2600  IF FA = 1 THEN P2 = P2 * .8
2610  IF FA = 3 THEN P2 = P2 * .9
2620  IF P3 > 1 THEN P3 = 1
2630  IF FA = 1 THEN P3 = P3 * .8
2640  IF FA = 3 THEN P3 = P3 * .9
2650  IF P4 > 1 THEN P4 = 1
2660  IF FA = 1 THEN P4 = P4 * .8
2670  IF FA = 3 THEN P4 = P4 * .9
2680  IF P5 > 1 THEN P5 = 1
2690  IF FA = 1 THEN P5 = P5 * .8
2700  IF FA = 3 THEN P5 = P5 * .9
2710  IF P6 > 1 THEN P6 = 1
2720  IF FA = 1 THEN P6 = P6 * .8
2730  IF FA = 3 THEN P6 = P6 * .9
2740  IF P7 > 1 THEN P7 = 1
2750  IF FA = 1 THEN P7 = P7 * .8
2760  IF FA = 3 THEN P7 = P7 * .9
2770  IF P8 > 1 THEN P8 = 1
2780  IF FA = 1 THEN P8 = P8 * .8
2790  IF FA = 3 THEN P8 = P8 * .9
2800  IF P9 > 1 THEN P9 = 1
2810  IF FA = 1 THEN P9 = P9 * .8
2820  IF FA = 3 THEN P9 = P9 * .9
2830  IF P0 > 1 THEN P0 = 1
2840  IF FA = 1 THEN P0 = P0 * .8
2850  IF FA = 3 THEN P0 = P0 * .9
2860  IF PA > 1 THEN PA = 1
2870  IF FA = 1 THEN PA = PA * .8
2880  IF FA = 3 THEN PA = PA * .9
2890  IF PB > 1 THEN PB = 1
2900  IF FA = 1 THEN PB = PB * .8
2910  IF FA = 3 THEN PB = PB * .9
2920 L0 = L1 + L2 + L3 + L4 + L5 + L6 + L7 + L8 + L9 + L0 + LA + LB
2930 00 = (P1 * L1) + (P2 * L2) + (P3 * L3) + (P4 * L4) + (P5 * L5) +
     (P6 * L6) + (P7 * L7) + (P8 * L8) + (P9 * L9) + (P0 * L0) + (PA *
     LA) + (PB * LB)
2940 AS = 00 / L0
2950  IF AS > 1 THEN AS = 1
2960  HOME : INVERSE : GOSUB 21380: PRINT "    * FRACTION OF HOT WATE
     R";: GOSUB 21380: PRINT "       SUPPLIED BY SOLAR";: GOSUB 21380
     : GOSUB 21380: NORMAL
2965  GOSUB 22200:TM = Y5 + 1: GOSUB 22100: PRINT
2966 LM = 5: GOSUB 22120: PRINT
2970  PRINT JA$;" ="; TAB( 20); INT (P1 * 100) / 100
```

```
2980  PRINT FB$;" =";  TAB( 20);  INT (P2 * 100) / 100
2990  PRINT MR$;" =";  TAB( 20);  INT (P3 * 100) / 100
3000  PRINT AP$;" =";  TAB( 20);  INT (P4 * 100) / 100
3010  PRINT MY$;" =";  TAB( 20);  INT (P5 * 100) / 100
3020  PRINT JE$;" =";  TAB( 20);  INT (P6 * 100) / 100
3030  PRINT JL$;" =";  TAB( 20);  INT (P7 * 100) / 100
3040  PRINT AG$;" =";  TAB( 20);  INT (P8 * 100) / 100
3050  PRINT SP$;" =";  TAB( 20);  INT (P9 * 100) / 100
3060  PRINT OT$;" =";  TAB( 20);  INT (P0 * 100) / 100
3070  PRINT NV$;" =";  TAB( 20);  INT (PA * 100) / 100
3080  PRINT DC$;" =";  TAB( 20);  INT (PB * 100) / 100
3085 LM = 0: GOSUB 22120
3090  PRINT : PRINT "ANNUAL =";  TAB( 20);  INT (AS * 100) / 100
3100  LET NS = (1 - AS) * (AG)
3110  PRINT
3115  PRINT "HIT ANY KEY TO CONTINUE . . .";: GET AK$: HOME : PRINT :
      PRINT
3120  PRINT "ANNUAL KWH OF ELEC USED"
3130  PRINT "AS BACKUP FOR SOLAR =";  TAB( 20);  INT (NS)
3140 ZR =  INT (ZL * AS * 10)
3150  PRINT : PRINT "SOLAR HEAT= "ZR / 10" MBTUS"
3160  PRINT : PRINT "PRESS ANY KEY TO CONTINUE . . .";: GET AK$
3165  TEXT : HOME
3180  IF FA = 1 THEN FC = 500
3190  IF FA = 1 THEN VC = 215
3200  IF FA = 2 THEN FC = 1200
3210  IF FA = 2 THEN VC = 325
3220  IF FA = 3 THEN FC = 700
3230  IF FA = 3 THEN VC = 325
3240 KX = (100 - TX) / 100
3250  LET CS = FC + (VC * SA)
3260  GOTO 3300
3270  HOME : INVERSE : GOSUB 21380: PRINT "    * ESTIMATED INITIAL COS
      T OF";: GOSUB 21380: PRINT "      INSTALLED SYSTEM,$";: GOSUB 213
      80: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT
3280  PRINT "ENTER THE INTIAL COST OF THE SYSTEM TO THE NEAREST DOLLA
      R-LEAVE OFF $ SIGNS AND COMMAS."
3290 CV = CS:LO = 0:HI = 50000: GOSUB 39300:CS = CV
3300 0A = (CS - 1000) * .025
3310 0B = 1000 * .05
3320 SX = 0A + 0B
3330  IF CS < 1001 THEN SX = CS * .05
3340  IF SX > 125 THEN SX = 125
3350 C1 = (CS * KX) - SX
3360 OM = CS * .01
3370 S1 = CG * (AG - NS)
3380 N = 20
3390  IF ZQ = 1 THEN D = .046
3400  IF ZQ = 2 THEN D = .0278
3410 0B = D
3420 RR = (RQ + ES) / 2
3430 DP = DP + 1
3440 ZZ =  LOG ((1 + RR) / (1 + D))
3450 DP =  LOG (1 + C1 / (S1 - OM) * (RR - D)) / ZZ
3460  IF AA = 2 THEN D = .0278
3470  PRINT
3480  HOME : INVERSE : GOSUB 21380: PRINT "      * EXPECTED FIRST YEAR
      "";: GOSUB 21380: PRINT "        ECONOMIC PERFORMANCE";: GOSUB 21
      380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT
3500  PRINT "CAPITAL CST OF SYSTM =";  TAB( 25);"$";  INT (CS)
```

```
3510 RX = 1 - KX
3520 FX = CS * RX
3530  PRINT
3540  PRINT "FEDERAL TAX CR.=";  TAB( 25);"$";  INT (FX)
3550  PRINT : PRINT "STATE TAX CR.=";  TAB( 25);"$";  INT (SX)
3560  PRINT : PRINT "FIRST YR CST W/TX CR.=";  TAB( 25);"$";  INT (C1)
3570  PRINT : PRINT "O & M COSTS =";  TAB( 25);"$";  INT (OM)
3580  PRINT : PRINT "FIRST YR SAVINGS =";  TAB( 25);"$";  INT (S1)
3590  PRINT : PRINT
3600  PRINT : PRINT "HIT ANY KEY TO CONTINUE . . .";: GET AK$
3610  HOME : INVERSE : PRINT "     * EXPECTED LONG TERM";: GOSUB 21380: GOSUB 21380
     : PRINT "        ECONOMIC PERFORMANCE";: GOSUB 21380: GOSUB 21380
     : NORMAL : PRINT : PRINT
3620  PRINT "DISCOUNTED PAYBACK . . . . . " INT (DP)" YRS"
3630  PRINT
3640 S = 0
3650 RP = 0
3660 PV = ((1 + D) ^ N - 1) / (D * (1 + D) ^ N)
3670 M = OM * PV
3680 RG = 0
3690 NR = 0
3700 NM = 200 * .01 * PV
3710 EP = (NS * CG) * PW
3720 EN = (AG * CG) * PW
3730 NC = NR - S + NM + RG + EN
3740 LC = C1 - S + M + RP + EP
3760  PRINT "LIFECYCLE COST /SOLAR . . . . . $";  INT (LC)
3770  PRINT
3780 NC = NC * 100:NC =  INT (NC):NC = NC / 100
3790  PRINT
3800  PRINT "LIFECYCLE COST /ELECTRICITY . . $";  INT (NC)
3810  PRINT
3820 NC = NC - LC
3830  PRINT
3850  PRINT "NET SAVINGS . . . . . $";  INT (NC)
3860  GOTO 5150
3870 SA = SA + 1
3880 ZB = ZB + 1
3890  NORMAL
3900 XX = NS
3910 A = 11.6:B = 1.18
3920 C = 3.86:E = 2.32
3930 EX = .94
3940 RF = 100
3950 X = SA * X1 * (RF - (A1)) * 31 * 24 * 3600 / (L1 * 10 ^ 9)
3960 X = X * (A + (B * TH) + (C * T1) - (E * A1)) / (RF - (A1))
3970 Y = Y1 * EX * I1 * 10 ^ 6 * 31 * SA / (L1 * 10 ^ 9)
3980 P1 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.0018 * X ^ 2)
     + (.0215 * Y ^ 3)
3990 X = SA * X1 * (RF - (A2)) * 28 * 24 * 3600 / (L2 * 10 ^ 9)
4000 X = X * (A + (B * TH) + (C * T2) - (E * A2)) / (RF - (A2))
4010 Y = Y1 * EX * I2 * 10 ^ 6 * 28 * SA / (L2 * 10 ^ 9)
4020 P2 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.0018 * X ^ 2)
     + (.0215 * Y ^ 3)
4030 X = SA * X1 * (RF - (A3)) * 31 * 24 * 3600 / (L3 * 10 ^ 9)
4040 X = X * (A + (B * TH) + (C * T3) - (E * A3)) / (RF - (A3))
4050 Y = Y1 * EX * I3 * 10 ^ 6 * 31 * SA / (L3 * 10 ^ 9)
4060 P3 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.0018 * X ^ 2)
     + (.0215 * Y ^ 3)
4070 X = SA * X1 * (RF - (A4)) * 30 * 24 * 3600 / (L4 * 10 ^ 9)
```

```
4080 X = X * (A + (B * TH) + (C * T4) - (E * A4)) / (RF - (A4))
4090 Y = Y1 * EX * I4 * 10 ^ 6 * 30 * SA / (L4 * 10 ^ 9)
4100 P4 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
4110 X = SA * X1 * (RF - (A5)) * 31 * 24 * 3600 / (L5 * 10 ^ 9)
4120 X = X * (A + (B * TH) + (C * T5) - (E * A5)) / (RF - (A5))
4130 Y = Y1 * EX * I5 * 10 ^ 6 * 31 * SA / (L5 * 10 ^ 9)
4140 P5 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
4150 X = SA * X1 * (RF - (A6)) * 30 * 24 * 3600 / (L1 * 10 ^ 9)
4160 X = X * (A + (B * TH) + (C * T6) - (E * A6)) / (RF - (A6))
4170 Y = Y1 * EX * I6 * 10 ^ 6 * 30 * SA / (L6 * 10 ^ 9)
4180 P6 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
4190 X = SA * X1 * (RF - (A7)) * 31 * 24 * 3600 / (L7 * 10 ^ 9)
4200 X = X * (A + (B * TH) + (C * T7) - (E * A7)) / (RF - (A7))
4210 Y = Y1 * EX * I7 * 10 ^ 6 * 31 * SA / (L7 * 10 ^ 9)
4220 P7 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
4230 X = SA * X1 * (RF - (AB)) * 31 * 24 * 3600 / (LB * 10 ^ 9)
4240 X = X * (A + (B * TH) + (C * TB) - (E * AB)) / (RF - (AB))
4250 Y = Y1 * EX * IB * 10 ^ 6 * 31 * SA / (LB * 10 ^ 9)
4260 P8 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
4270 X = SA * X1 * (RF - (A9)) * 30 * 24 * 3600 / (L9 * 10 ^ 9)
4280 X = X * (A + (B * TH) + (C * T9) - (E * A9)) / (RF - (A9))
4290 Y = Y1 * EX * I9 * 10 ^ 6 * 30 * SA / (L9 * 10 ^ 9)
4300 P9 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
4310 X = SA * X1 * (RF - (A0)) * 31 * 24 * 3600 / (L0 * 10 ^ 9)
4320 X = X * (A + (B * TH) + (C * T0) - (E * A0)) / (RF - (A0))
4330 Y = Y1 * EX * I0 * 10 ^ 6 * 31 * SA / (L0 * 10 ^ 9)
4340 P0 = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
4350 X = SA * X1 * (RF - (AY)) * 30 * 24 * 3600 / (LA * 10 ^ 9)
4360 X = X * (A + (B * TH) + (C * TA) - (E * AY)) / (RF - (AY))
4370 Y = Y1 * EX * IA * 10 ^ 6 * 30 * SA / (LA * 10 ^ 9)
4380 PA = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
4390 X = SA * X1 * (RF - (AZ)) * 31 * 24 * 3600 / (LB * 10 ^ 9)
4400 X = X * (A + (B * TH) + (C * TB) - (E * AZ)) / (RF - (AZ))
4410 Y = Y1 * EX * IB * 10 ^ 6 * 31 * SA / (LB * 10 ^ 9)
4420 PB = (1.029 * Y) - (.065 * X) - (.245 * Y ^ 2) + (.001B * X ^ 2)
     + (.0215 * Y ^ 3)
4430  IF P1 > 1 THEN P1 = 1
4440  IF FA = 1 THEN P1 = P1 * .8: IF FA = 3 THEN P1 = P1 * .9
4450  IF P2 > 1 THEN P2 = 1
4460  IF FA = 1 THEN P2 = P2 * .8: IF FA = 3 THEN P2 = P2 * .9
4470  IF P3 > 1 THEN P3 = 1
4480  IF FA = 1 THEN P3 = P3 * .8: IF FA = 3 THEN P3 = P3 * .9
4490  IF P4 > 1 THEN P4 = 1
4500  IF FA = 1 THEN P4 = P4 * .8: IF FA = 3 THEN P4 = P4 * .9
4510  IF P5 > 1 THEN P5 = 1
4520  IF FA = 1 THEN P5 = P5 * .8: IF FA = 3 THEN P5 = P5 * .9
4530  IF P6 > 1 THEN P6 = 1
4540  IF FA = 1 THEN P6 = P6 * .8: IF FA = 3 THEN P6 = P6 * .9
4550  IF P7 > 1 THEN P7 = 1
4560  IF FA = 1 THEN P7 = P7 * .8: IF FA = 3 THEN P7 = P7 * .9
4570  IF P8 > 1 THEN P8 = 1
4580  IF FA = 1 THEN P8 = P8 * .8: IF FA = 3 THEN P8 = P8 * .9
```

```
4590  IF P9 > 1 THEN P9 = 1
4600  IF FA = 1 THEN P9 = P9 * .8: IF FA = 3 THEN P9 = P9 * .9
4610  IF P0 > 1 THEN P0 = 1
4620  IF FA = 1 THEN P0 = P0 * .8: IF FA = 3 THEN P0 = P0 * .9
4630  IF PA > 1 THEN PA = 1
4640  IF FA = 1 THEN PA = PA * .8: IF FA = 3 THEN PA = PA * .9
4650  IF PB > 1 THEN PB = 1
4660  IF FA = 1 THEN PB = PB * .8: IF FA = 3 THEN PB = PB * .9
4670 LQ = L1 + L2 + L3 + L4 + L5 + L6 + L7 + L8 + L9 + L0 + LA + LB
4680 QQ = (P1 * L1) + (P2 * L2) + (P3 * L3) + (P4 * L4) + (P5 * L5) +
     (P6 * L6) + (P7 * L7) + (P8 * L8) + (P9 * L9) + (P0 * L0) + (PA *
     LA) + (PB * LB)
4690 AS = QQ / LQ
4700  IF AS > 1 THEN AS = 1
4710 SS = (1 - AS) * AG
4740  IF FA = 1 THEN FC = 500
4750  IF FA = 1 THEN VC = 215
4760  IF FA = 2 THEN FC = 1200
4770  IF FA = 2 THEN VC = 325
4780  IF FA = 3 THEN FC = 700
4790  IF FA = 3 THEN VC = 325
4800 CS = FC + (VC * SA)
4810 KX = (100 - TX) / 100
4820 QA = (CS - 1000) * .025
4830 QB = 1000 * .05
4840 SX = QA + QB
4850  IF CS < 1000 THEN SX = CS * .05
4860  IF SX > 125 THEN SX = 125
4870 C1 = (CS * KX) - SX
4880 OM = CS * .01
4890 N = 20
4900  IF ZQ = 1 THEN D = .046
4910  IF ZQ = 2 THEN D = .0278
4920 S = 0
4930 RP = 0
4940 PV = ((1 + D) ^ N - 1) / (D * (1 + D) ^ N)
4950 M = OM * PV
4960 RG = 0
4970 NR = 0
4980 NM = 200 * .01 * PV
4990 EP = (SS * CG) * PW
5000 EN = (AG * CG) * PW
5010 NC = NR - S + NM + RG + EN
5020 LC = C1 - S + M + RP + EP
5030 NS = NC - LC
5040  NORMAL
5050  PRINT
5060  PRINT "----------------------------"
5070  PRINT "SQR FT= " INT (SA * 10.76)
5080  PRINT "SOLAR FRACTION= ";( INT (AS * 100)) / 100
5090  PRINT "NET SAVINGS= $"; INT (NS)
5100  PRINT "----------------------------"
5110  IF NS > XX GOTO 3870
5120  IF NS = 0 THEN 3870
5130  IF ZB = 1 THEN 3870
5140  RETURN
5150 SIR = ((EN - EP) - (M - NM)) / C1 - (S + R)
5160  PRINT
5170 SN = SIR * 100
5180 SN =  INT (SN)
```

```
5190 SN = SN / 100
5200  PRINT : PRINT "SAVINGS INVESTMENT RATIO . . . . ";SN
5210  PRINT : PRINT : PRINT
5220  PRINT "HIT ANY KEY TO CONTINUE . . .";: GET AK$
5230  HOME : INVERSE : GOSUB 21380: PRINT "          * WOULD YOU LIKE TO S
      EE";: GOSUB 21380: PRINT "          THE FINANCIAL ASSUMPTIONS";: GOSUB
      21380: PRINT "          USED IN THE ANALYSIS?";: GOSUB 21380: GOSUB
      21380: NORMAL : PRINT : PRINT : PRINT
5240  PRINT "1) YES": PRINT "2) NO": PRINT
5250 CV = 2:LO = 1:HI = 2: GOSUB 39300: IF CV = 2 THEN 5400
5260  HOME
5270  HOME : INVERSE : GOSUB 21380: PRINT "FINANCIAL PARAMETERS FOR A
      NALYSIS";: GOSUB 21380: GOSUB 21380: NORMAL : PRINT
5280  PRINT
5290  PRINT
5300  PRINT  TAB( 12);"DISCOUNT RATE=  ";(D + .08) * 100"%"
5310  PRINT
5320  PRINT  TAB( 12);"COST OF ELEC.= $"CG"/KWH"
5330  PRINT
5340  PRINT  TAB( 12);"FUEL PRICE ESCAL RATE= "(ES * 100) + 8"%"
5350  PRINT
5360  PRINT  TAB( 12);"INFLATION RATE = 8%"
5370  PRINT
5380  PRINT  TAB( 12);"LIFE OF INVESTMENT=  20 YEARS"
5390  PRINT : PRINT : PRINT "HIT ANY KEY TO CONTINUE . . .";: GET AK$

5400  HOME : IF PT$ = "N" THEN 5440
5410  HOME : INVERSE : GOSUB 21380: PRINT " * WOULD YOU LIKE A PRINTE
      D COPY?";: GOSUB 21380: GOSUB 21380: NORMAL : PRINT
5420  PRINT "1) YES": PRINT "2) NO": PRINT
5430 CV = 2:LO = 1:HI = 2: GOSUB 39300: IF CV = 1 THEN  GOSUB 5960
5435 P = 0:V = 0
5440  HOME : INVERSE : GOSUB 21380: PRINT "  * WHERE TO NOW?";: GOSUB
      21380: GOSUB 21380: NORMAL : PRINT
5450 CV = 0:LO = 0:HI = 128: GOSUB 39300
5460  END
5470 N = 2
5480  HOME : INVERSE : GOSUB 21380: PRINT " * WHAT IS THE COLLECTOR H
      EAT TRANSFER";: GOSUB 21380: PRINT "    COEFFICIENT (FR-UL)?";: GOSUB
      21380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT
5490 CV = X(1):LO = .05:HI = .99: GOSUB 39300:X(1) = CV
5500  NORMAL
5510  IF X(1) = 0 THEN X(1) = .68
5520 Y(1) = 0
5530 X(2) = 0
5540  HOME : INVERSE : GOSUB 21380: PRINT "  * WHAT IS THE COLLECTOR
      TRANS-";: GOSUB 21380: PRINT "MITTANCE/ABSORBANCE PRODUCT (FR-TA
      )?";: GOSUB 21380: GOSUB 21380: NORMAL : PRINT : PRINT : PRINT
5550 CV = Y(2):LO = .1:HI = .9: GOSUB 39300:Y(2) = CV
5560 X1 = 0:Y1 = 0
5570 XY = 0:X2 = 0
5580  FOR I = 1 TO N
5590 X1 = X1 + X(I)
5600 Y1 = Y1 + Y(I)
5610 XY = XY + X(I) * Y(I)
5620 X2 = X2 + X(I) * X(I)
5630  NEXT I
5640 J = N * X2 - X1 * X1
5650  IF J <  > 0 THEN 5670
5660  PRINT "NO SOLUTION FOUND": FOR X = 1 TO 1000: NEXT X:X(1) = 0:Y
```

```
    (2) = 0: GOTO 5510
5670 M = (N * XY - X1 * Y1) / J
5680 M =  INT (1E3 * M + .5) / 1E3
5690 B = (Y1 * X2 - X1 * XY) / J
5700  IF  ABS (B) = B THEN B$ = "+"
5710  RETURN
5720  REM
5750 K = ES
5760 P = 0
5770 E = .06
5780 RD = E
5790 AD = ((1 + D) / (1 + E)) - 1
5800 AB = ((1 + D) / (1 + K)) - 1
5810  FOR N = 1 TO 10
5820 P(N) = 1 / ((1 + AD) ^ N)
5830  NEXT N
5840  FOR N = 11 TO 20
5850 V(N) = 1 / ((1 + AB) ^ N)
5860  NEXT N
5870  FOR N = 1 TO 10
5880 P = P + P(N)
5890  NEXT N
5900  FOR N = 11 TO 20
5910 V = V + V(N)
5920  NEXT N
5930 PW = P + V
5940 PZ = PW
5950  RETURN
5960  REM  PRINT SUBROUTINE
5970 D$ = ""
5980  PRINT D$;"PR#1"
5990  PR# 1
6000  PRINT "****** SOLAR HOT WATER HEATING ANALYSIS ******"
6010  PRINT : PRINT
6020  PRINT : PRINT "LOCATION= "RE$", MONTANA"
6030  PRINT : PRINT "NO. PERSONS IN HOUSEHOLD= ";ZP
6040  PRINT : PRINT "HOT WATER USED PER DAY= "; INT (Q * ZP)" GALLONS
      "
6050  PRINT
6060  PRINT "HOT WATER TEMP.= ";(TH * 1.8) + 32" DEGREES"
6070  PRINT
6080  PRINT "ANN. KWH USED FOR HOT WATER= "; INT (AG)
6090  PRINT
6100  PRINT "OPTIMAL FT2 OF COLLECTOR= "; INT (SB * 10.7639)
6110  PRINT
6120  PRINT "AREA ANALYZED= " INT (SA * 10.764)" FT2"
6130  PRINT
6140  PRINT "ANN. SOLAR FRACTION OF HOT WATER= " INT (AS * 100) / 100

6150  PRINT
6160  PRINT "ANN. SOLAR ENERGY FROM SYSTEM= ";ZR / 10" MBTUS"
6170  PRINT
6180  PRINT "ANN. KWH USED FOR BACKUP= "; INT (NS * 100) / 100
6190  PRINT
6200  PRINT "INTIAL COST OF SYSTEM= $"; INT (CS)
6210  PRINT
6220  PRINT "FEDERAL TAX CREDIT= $"; INT (FX)
6230  PRINT
6240  PRINT "STATE TAX CREDIT= $"; INT (SX)
6250  PRINT
```

```
6260  PRINT "ANN. O&M COSTS= $"; INT (OM)
6270  PRINT
6280  PRINT "FIRST YEAR SAVINGS= $"; INT (S1)
6290  PRINT
6300  PRINT "DISCOUNTED PAYBACK= "; INT (DP)" YEARS"
6310  PRINT
6320  PRINT "NET SAVINGS IN CURRENT DOLLARS=  $"; INT (NC)
6330  PRINT
6340  PRINT "ASSUMED DISCOUNT RATE= ";(D + .08) * 100"%"
6350  PRINT
6360  PRINT "COST OF ELECTRICITY= $"CG"/KWH"
6370  PRINT
6380  PRINT "FUEL PRICE ESCALATION RATE= ";(ES * 100) + 8"%"
6390  PRINT
6400  PRINT "INFLATION RATE= 8%"
6410  PRINT D$;"PR#0"
6420  RETURN
10000  REM
10010  REM * GET AND READ CITY FILE *
10020  REM
10050  HOME : INVERSE : GOSUB 21380
10060  PRINT "* ENTER THE NUMBER OF THE CITY NEAREST ": PRINT "   YOU
     R LOCATION AND PRESS RETURN ":: GOSUB 21380: GOSUB 21380: NORMAL
     : VTAB 6
10070 A = 1:B = 10:LM = 0:TM = 5:BM = 20:WW = 13: GOSUB 22070
10090  FOR I = A TO B: PRINT I;".";FI$(I): NEXT
10100  IF B < 30 THEN A = A + 10:B = B + 10:LM = LM + 13: GOSUB 22120
     : HOME : GOTO 10090
10110  PRINT : TEXT : VTAB 20:LO = 1:HI = 30: GOSUB 20170: REM  CHOOS
     E CITY
10115 RE$ = FI$(A)
10120  GOSUB 21120: GOSUB 21140: REM  OPEN AND READ
10130  INPUT I
10150  FOR J = 1 TO I
10160 : INPUT A(J)
10170  NEXT J
10180  GOSUB 21160
10190  RETURN
10390  REM  * INITIALIZE CITY NAMES  *
10400  FOR I = 1 TO 30: READ FI$(I): NEXT
10410  DATA   ANACONDA,BILLINGS,BOZEMAN,BROWNING,BUTTE,CHOTEAU,COLSTR
     IP,DILLON,ENNIS,FT BENTON
10420  DATA  GLASGOW,GLENDIVE,GT FALLS,HAMILTON,HARLOWTON,HAVRE,HELE
     A,JORDAN,KALISPELL,LEWISTOWN
10430  DATA    LIBBY,LIVINGSTN,MILES CITY,MISSOULA,OPHEIM,PLENTYWOOD,RED
     LODGE,SIDNEY,TROY,WOLF POINT
10440  RETURN
10500  REM
10510  REM  * READ DEFAULTS *
10520  REM
10530  READ A,ZP,PY,TH,FA,AA,DE,Z,BO,SA,X(1),Y(2),CG,TX
10540  DATA      17,4,2,60,2,2,2,1,2,7.43225039,.68,.72,.036,40
10550 FA$(1) = "OWNER BUILT AND INSTALLED"
10555 FA$(2) = "COMMERCIAL PURCHASE AND INSTALLATION
10560 FA$(3) = "COMMERCIAL PURCHASE,OWNER INSTALLATION"
10565 AA$(1) = "BANK LOAN OR OTHER COMMERCIAL LOAN"
10570 AA$(2) = "ALTERNATIVE INVESTMENT"
10575 AA$(3) = "LOW INTEREST UTILITY LOAN"
10580 Z$(1) = "INSULATED"
10585 Z$(2) = "UNINSULATED"
```

```
11000  VTAB 16: PRINT : GOSUB 24144: GOSUB 24202: PRINT : REM     RTN=
    ACCEPT
11010  GOSUB 24142: GOSUB 24224: PRINT : REM  ESC=RESTART
11020  GOSUB 24118: GOSUB 24228: PRINT : REM CTRL-N=SAME VALUES, NEW
    CITY
11030  GOSUB 24126: GOSUB 24226: PRINT : REM  CTRL-R=RETURN TO BASE C
    ASE
11040  GOSUB 24124: GOSUB 24222: PRINT : RETURN : REM  CTRL-O=QUIT


      ****************
   * UTILITY SUBROUTINES *
   ****************
20100  REM
20110  REM
20120  REM ****************
20130  REM **SELECT & GET **
20140  REM ****************
20150  REM
20160  REM
20170  PRINT : PRINT "      YOUR SELECTION =>  ";
20180  GOSUB 20370:A =  VAL (A$): IF A < LO OR A > HI THEN 20170
20190  RETURN
20200  PRINT : PRINT "ANY CHANGES? ";: GOSUB 20790: RETURN
20220  PRINT "ANY MORE? ";: GOSUB 20790: RETURN
20230  PRINT "CHANGE WHICH ONE? ==> ";: GOSUB 20370:A =  VAL (A$)
20240  IF A < LO OR A > HI THEN 20230
20250  PRINT : RETURN
20370 A$ = "":A = 0:L = 0: REM   L =STRING LENGTH
20380  ONERR  GOTO 21470
20390  GET AE$
20400  IF AE$ =  CHR$ (13) THEN  PRINT : RETURN
20410  IF AE$ =  CHR$ (27) THEN  RETURN
20420  IF AE$ =  CHR$ (14) THEN  RETURN
20430  IF AE$ =  CHR$ (18) THEN  RETURN
20440  IF AE$ =  CHR$ (17) THEN  END
20450  REM
20460  REM
20470  IF AE$ =  CHR$ (8) THEN  PRINT  CHR$ (8);: GOSUB 20510:L = L -
    1:A$ =  LEFT$ (A$,L): GOTO 20390
20480  PRINT AE$;
20490  REM
20500 A$ = A$ + AE$:L = L + 1: GOTO 20390
20510  IF L - 1 <  = 0 THEN  POP : GOTO 20370
20520  RETURN
21100  FOR I = 1 TO 350: NEXT : RETURN
21120  PRINT D$;"OPEN ";FI$(A): RETURN
21130  PRINT D$;"DELETE ";FI$(A): RETURN
21140  PRINT D$;"READ ";FI$(A): RETURN
21150  PRINT D$;"WRITE ";FI$(A): RETURN
21160  PRINT D$;"CLOSE "FI$(A): PRINT : PRINT  TAB( 10)"FILE CLOSED":
    GOSUB 21100: RETURN
21300  REM
21310  REM
21320  REM ******************
21330  REM * MODULE HEADERS *
21340  REM ******************
21350  REM
21360  REM
21370  HOME : HTAB 4: INVERSE : PRINT HDR$(HDR): NORMAL : PRINT : RETURN
```

```
21380  GOSUB 22200: VTAB Y5 + 1: HTAB X5 + 1: FOR I = 1 TO 39 - X5: PRINT
     " ";: NEXT : PRINT : RETURN
21400  REM
21410  REM
21420  REM ******************
21430  REM * ERROR HANDLING *
21440  REM ******************
21450  REM
21460  REM
21470  REM      *  ERROR HANDLING.DOS  *
21480 X =  PEEK (222): POKE 216,0
21500  IF X = 7 THEN  PRINT "VOLUME MISMATCH IN LINE "; PEEK (218) +
     256 *  PEEK (219);" **": STOP
21502  IF X = 1 THEN  PRINT "LANGUAGE NOT AVAILABLE": STOP
21504  IF X = 2 OR X = 3 THEN  PRINT "RANGE ERROR IN LINE "; PEEK (21
     8) + 256 *  PEEK (219);" **": STOP
21506  IF X = 4 THEN  PRINT "DISK WRITE PROTECTED": STOP
21508  IF X = 5 THEN  PRINT "END OF DATA IN LINE "; PEEK (218) + 256 *
     PEEK (219);" **": STOP
21510  IF X = 6 THEN  PRINT "FILE NOT FOUND IN LINE "; PEEK (218) + 2
     56 *  PEEK (219);" **": STOP
21512  IF X = 8 THEN  PRINT "I/O ERROR": STOP
21514  IF X = 9 THEN  PRINT "DISK FULL": STOP
21516  IF X = 10 THEN  PRINT "FILE LOCKED": STOP
21518  IF X = 11 THEN  PRINT "SYNTAX ERROR IN LINE "; PEEK (218) + 25
     6 *  PEEK (219);" **": STOP
21520  IF X = 12 THEN  PRINT "NO BUFFERS AVAILABLE IN LINE "; PEEK (2
     18) + 256 *  PEEK (219);" **": STOP
21522  IF X = 13 THEN  PRINT "FILE TYPE MISMATCH IN LINE "; PEEK (218
     ) + 256 *  PEEK (219);" **": STOP
21524  IF X = 14 THEN  PRINT "PROGRAM TOO LARGE": STOP
21526  IF X = 15 THEN  PRINT "NOT DIRECT COMMAND": STOP
21528  IF X = 16 THEN  PRINT "SYNTAX ERROR IN LINE "; PEEK (218) + 25
     6 *  PEEK (219);" **": STOP
21530  IF X = 22 THEN  PRINT "RETURN WITHOUT GOSUB IN LINE "; PEEK (2
     18) + 256 *  PEEK (219);" **": STOP
21532  IF X = 42 THEN  PRINT "OUT OF DATA IN LINE "; PEEK (218) + 256
     *  PEEK (219);" **": STOP
21534  IF X = 53 THEN  PRINT "ILLEGAL QUANTITY IN LINE "; PEEK (218) +
     256 *  PEEK (219);" **": STOP
21536  IF X = 69 THEN  PRINT "OVERFLOW ERROR IN LINE "; PEEK (218) +
     256 *  PEEK (219);" **": STOP
21538  IF X = 77 THEN  PRINT "OUT OF MEMORY IN LINE "; PEEK (218) + 2
     56 *  PEEK (219);" **": STOP
21540  IF X = 90 THEN  PRINT "UNDEFINED STATEMENT IN LINE "; PEEK (21
     8) + 256 *  PEEK (219);" **": STOP
21542  IF X = 107 THEN  PRINT "BAD SUBSCRIPT IN LINE "; PEEK (218) +
     256 *  PEEK (219);" **": STOP
21544  IF X = 120 THEN  PRINT "REDIMENSIONED ARRAY IN LINE "; PEEK (2
     18) + 256 *  PEEK (219);" **": STOP
21546  IF X = 133 THEN  PRINT "DIVISION BY ZERO IN LINE "; PEEK (218)
     + 256 *  PEEK (219);" **": STOP
21548  IF X = 163 THEN  PRINT "TYPE MISMATCH IN LINE "; PEEK (218) +
     256 *  PEEK (219);" **": STOP
21550  IF X = 176 THEN  PRINT "STRING TOO LONG IN LINE "; PEEK (218) +
     256 *  PEEK (219);" **": STOP
21552  IF X = 191 THEN  PRINT "FORMULA TOO COMPLEX IN LINE "; PEEK (2
     18) + 256 *  PEEK (219);" **": STOP
21554  IF X = 224 THEN  PRINT "UNDEFINED FUNCTION IN LINE "; PEEK (21
     8) + 256 *  PEEK (219);" **": STOP
```

```
21556  IF X = 254 THEN  PRINT "BAD RESPONSE TO INPUT IN LINE "; PEEK
     (218) + 256 *  PEEK (219);" **": STOP
21558  IF X = 255 THEN  PRINT "CONTROL-C IN LINE "; PEEK (218) + 256 *
     PEEK (219);" **": STOP
21560  GOTO 980
21800  REM
21810  REM
21820  REM  **********************
21830  REM  * PRINTER AND DRIVE *
21840  REM  **********************
21850  REM
21860  PRINT "DO YOU WANT A HARD COPY? "; GOSUB 20790
21870  IF A$ = "N" THEN  RETURN
21880  PRINT D$;"PR#" +  STR$ (PS): RETURN
21890  PRINT D$;"PR#0": RETURN
22000  REM
22010  REM
22020  REM ******************
22030  REM * SCREEN SETUPS *
22040  REM ******************
22050  REM
22060  REM
22070  POKE 34,TM: POKE 35,BM: POKE 32,LM: POKE 33,WW: RETURN
22080  REM
22090  REM
22100  POKE 34,TM: RETURN : REM TOP
22110  POKE 35,BM: RETURN : REM BOTTOM
22120  POKE 32,LM: POKE 33,40 - LM: RETURN : REM    LEFT AND WIDTH
22130  POKE 33,WW: RETURN : REM WINDOW WIDTH
22140  REM
22160  REM
22170  REM
22180  POKE 36,HC: RETURN : REM HORIZONTAL CURSOR
22200 X5 =  PEEK (36):Y5 =  PEEK (37): RETURN
24000  REM
24002  REM
24004  REM **********************
24006  REM * SINGLE KEY OPTIONS *
24008  REM **********************
24010  REM
24012  REM
24014  INVERSE : PRINT "RTN";: NORMAL : PRINT "=ACCEPT ": RETURN : REM
     CHR$(13)
24016  INVERSE : PRINT "SPC";: NORMAL : PRINT "=NEXT EVT ": RETURN : REM
     CHR$(32)
24018  INVERSE : PRINT "ESC";: NORMAL : PRINT "=NEXT SWMR ":: RETURN
     : REM  CHR$(27)
24100  INVERSE : PRINT "CTRL-A";: NORMAL : RETURN : REM  CHR$(1)
24102  INVERSE : PRINT "CTRL-B";: NORMAL : RETURN : REM  CHR$(2)
24104  INVERSE : PRINT "CTRL-C";: NORMAL : RETURN : REM  CHR$(3)
24106  INVERSE : PRINT "CTRL-D";: NORMAL : RETURN : REM  CHR$(4)
24108  INVERSE : PRINT "CTRL-E";: NORMAL : RETURN : REM  CHR$(5)
24110  INVERSE : PRINT "CTRL-F";: NORMAL : RETURN : REM  CHR$(6)
24112  INVERSE : PRINT "CTRL-I";: NORMAL : RETURN : REM  CHR$(9)
24114  INVERSE : PRINT "CTRL-K";: NORMAL : RETURN : REM  CHR$(11)
24116  INVERSE : PRINT "CTRL-L";: NORMAL : RETURN : REM  CHR$(12)
24118  INVERSE : PRINT "CTRL-N";: NORMAL : RETURN : REM  CHR$(14)
24120  INVERSE : PRINT "CTRL-O";: NORMAL : RETURN : REM  CHR$(15)
24122  INVERSE : PRINT "CTRL-P";: NORMAL : RETURN : REM  CHR$(16)
24124  INVERSE : PRINT "CTRL-Q";: NORMAL : RETURN : REM  CHR$(17)
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24126  INVERSE : PRINT "CTRL-R";: NORMAL : RETURN : REM  CHR$(18)
24128  INVERSE : PRINT "CTRL-S";: NORMAL : RETURN : REM  CHR$(19)
24130  INVERSE : PRINT "CTRL-T";: NORMAL : RETURN : REM  CHR$(20)
24132  INVERSE : PRINT "CTRL-V";: NORMAL : RETURN : REM  CHR$(22)
24134  INVERSE : PRINT "CTRL-W";: NORMAL : RETURN : REM  CHR$(23)
24136  INVERSE : PRINT "CTRL-Y";: NORMAL : RETURN : REM  CHR$(25)
24138  INVERSE : PRINT "CTRL-Z";: NORMAL : RETURN : REM  CHR$(26)
24140  REM
24142  INVERSE : PRINT "ESC";: NORMAL : RETURN : REM   CHR$(32)
24144  INVERSE : PRINT "RTN";: NORMAL : RETURN : REM   CHR$(13)
24146  INVERSE : PRINT "SPC";: NORMAL : RETURN : REM   CHR$(32)
24148  REM
24150  REM
24152  REM
24200  REM
24202  PRINT "=ACCEPT VALUE ";: RETURN
24204  PRINT "=DEFAULT VALUE ";: RETURN
24206  PRINT "=NEXT ITEM ";: RETURN
24208  PRINT "=INSERT ";: RETURN
24210  PRINT "=DELETE ";: RETURN
24212  PRINT "=ADD ";: RETURN
24214  PRINT "=REPLACE ";: RETURN
24216  PRINT "=CONTINUE ";: RETURN
24218  PRINT "=CALCULATE ";: RETURN
24220  PRINT "=RETURN TO MENU ";: RETURN
24222  PRINT "=QUIT";: RETURN
24224  PRINT "=RESTART,VALUES INTACT ";: RETURN
24226  PRINT "=RETURN VALUES TO BASE CASE ";: RETURN
24228  PRINT "=SAME VALUES, NEW CITY";: RETURN
38000  REM
38010  REM
38020  REM ***************
38030  REM * GET VALUE 1 *
38040  REM ***************
38050  REM
38060  REM
38100  GOSUB 22200: REM X1,Y1
38110  PRINT CV: RETURN
38200  REM
38210  REM
38220  REM ***************
38230  REM * GET VALUE 2 *
38240  REM ***************
38250  REM
38260  REM
38300  VTAB Y5 + 1: HTAB X5 + 1
38310  GOSUB 20370: GOSUB 39100
38320  RETURN
39000  REM
39010  REM
39020  REM ***********************
39030  REM * KEY TESTS, EVENTS *
39040  REM ***********************
39050  REM
39060  REM
39100  IF A$ <  > "" THEN LD =  LEN ( STR$ ( VAL (A$)))
39105  VTAB Y5 + 1: HTAB X5 + 1 + LD: CALL  - 868
39110  IF AE$ =  CHR$ (13) AND  VAL (A$) >  = LO AND  VAL (A$) <  = H
     I AND A$ <  > "" THEN CV =  VAL (A$)
39115  IF A$ <  > "" AND  VAL (A$) < LO OR  VAL (A$) > HI THEN  POP :
```

```
    GOTO 38300
39120  IF AE$ =  CHR$ (27) THEN  HOME : POP : POP : GOTO 680
39130  IF AE$ =  CHR$ (14) THEN  GOSUB 10050: POP : POP : GOTO 680
39140  IF AE$ =  CHR$ (18) THEN  RESTORE : GOSUB 10400: GOSUB 10530: POP
     : POP : GOTO 680
39150  RETURN
39300  PRINT "   CURRENT VALUE => ";: GOSUB 22200: PRINT CV:LD =  LEN
     ( STR$ (CV)): GOSUB 11000: REM   KEY TESTS
39310  GOSUB 38300: RETURN
49999  RETURN
50000  REM
50010  REM
50020  REM ******************
50030  REM * GOSUB LISTING *
50040  REM ******************
50050  REM
50060  REM
50070  GOSUB 20170: REM  "YOUR SELECTION?"
50080  GOSUB 20210: REM "ANY CHANGES?"
50090  GOSUB 20220: REM "ANY MORE?"
50100  GOSUB 20230: REM "CHANGE WHICH ONE?"
50110  REM
50150  REM
50160  GOSUB 20370: REM MULTIPLE GET
50170  GOSUB 20670: REM  ANY KEY TO CONTINUE
50180  GOSUB 20790: REM  "Y/N?"
50185  GOSUB 20820: REM "IS THIS OK?"
50190  REM
50200  GOSUB 21060: REM RA FILE OPEN
50210  GOSUB 21070: REM RA FILE READ
50220  GOSUB 21080: REM RA FILE WRITE
50230  GOSUB 21090: REM RA FILE CLOSE
50240  REM
50250  GOSUB 21100: REM DELAY FOR DISPLAY
50260  REM
50270  GOSUB 21120: REM SEQUENTIAL FILE OPEN
50280  GOSUB 21130: REM SEQUENTIAL FILE DELETE
50290  GOSUB 21140: REM SEQUENTIAL FILE READ
50300  GOSUB 21150: REM SEQUENTIAL FILE WRITE
50310  GOSUB 21160: REM SEQUENTIAL FILE CLOSE
50320  REM
50330  GOSUB 21170: REM  MON C,I,O
50340  GOSUB 21180: REM  NOMON C,I,O
50350  REM
50360  GOSUB 21360: REM PRINT MODULE HEADER
50370  GOSUB 21460: REM ONERR GOTO, DOS
50390  GOSUB 21730: REM CONVERT TIME TO DECIMAL
50400  REM
50410  GOSUB 21850: REM "HARD COPY?"
50420  GOSUB 21880: REM TURN ON PRINTER
50430  GOSUB 21890: REM TURN OFF PRINTER
50440  REM
50450  GOSUB 22070: REM  ALL SCREEN POKES
50460  GOSUB 22100: REM  SET TOP MARGIN
50470  GOSUB 22110: REM  SET BOTTOM MARGIN
50480  GOSUB 22120: REM  SET LEFT MARGIN
50490  GOSUB 22130: REM  SET WINDOW WIDTH
50500  GOSUB 22150: REM  SET CURSOR, HOR AND VERT
50510  GOSUB 22180: REM  SET CURSOR, HOR
50520  GOSUB 22190: REM  SET CURSOR, VERT
```

```
50530  GOSUB 24014: REM  "RTN=ACCEPT"
50540  GOSUB 24016: REM  "SPC=NEXT EVT"
50550  GOSUB 24018: REM  "ESC=NEXT SWMR"
50560  GOSUB 24100: REM   CTRL-A  1
50570  GOSUB 24102: REM   CTRL-B  2
50580  GOSUB 24104: REM   CTRL-C  3
50590  GOSUB 24106: REM   CTRL-D  4
50600  GOSUB 24108: REM   CTRL-E  5
50610  GOSUB 24110: REM   CTRL-F  6
50620  GOSUB 24112: REM   CTRL-I  9
50630  GOSUB 24114: REM   CTRL-K 11
50640  GOSUB 24116: REM   CTRL-L 12
50650  GOSUB 24118: REM   CTRL-N 14
50660  GOSUB 24120: REM   CTRL-O 15
50670  GOSUB 24122: REM   CTRL-P 16
50680  GOSUB 24124: REM   CTRL-Q 17
50690  GOSUB 24126: REM   CTRL-R 18
50700  GOSUB 24128: REM   CTRL-S 19
50710  GOSUB 24130: REM   CTRL-T 20
50720  GOSUB 24132: REM   CTRL-V 22
50730  GOSUB 24134: REM   CTRL-W 23
50740  GOSUB 24136: REM   CTRL-Y 25
50750  GOSUB 24138: REM   CTRL-Z 26
50760  REM
50770  GOSUB 24142: REM  ESC 32
50780  GOSUB 24144: REM  RTN 13
50790  GOSUB 24146: REM   SPC 32
50800  REM
50810  GOSUB 24202: REM  "ACCEPT"
50820  GOSUB 24204: REM  "DEFAULT"
50830  GOSUB 24206: REM  "NEXT ITEM"
50840  GOSUB 24208: REM  "INSERT"
50850  GOSUB 24210: REM  "DELETE"
50860  GOSUB 24212: REM  "ADD"
50870  GOSUB 24214: REM  "REPLACE"
50880  GOSUB 24216: REM  "CONTINUE"
50890  GOSUB 24218: REM  "CALCULATE"
50900  GOSUB 24220: REM  "RTN TO MENU"
50910  GOSUB 24222: REM  "QUIT"
51000  GOSUB 24014: REM "RTN=ACCEPT;ESC=QUIT"
51010  REM
```

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